PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2001-250114

(43)Date of publication of application : 14.09.2001

(51)Int.Cl. G06T 3/00
H04N 1/387
H04N 5/262

(21)Application number : 2000-261565

(22)Date of filing : 30.08.2000

(71)Applicant : RICOH CO LTD

(72)Inventor : MURATA NORIHIKO
KITAGUCHI TAKASHI
AOKI SHIN

(30)Priority

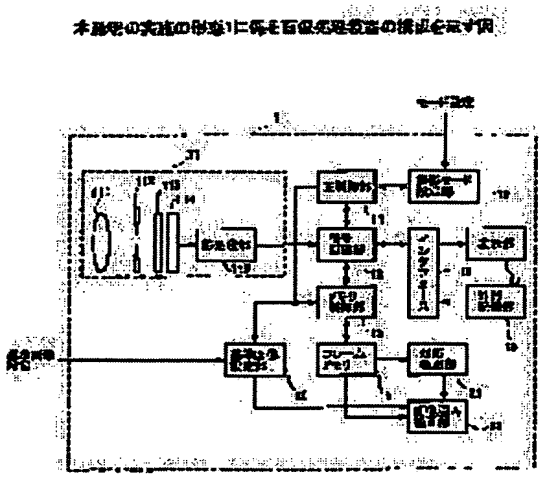
Priority number : 11375651 Priority date : 28.12.1999 Priority country : JP

(54) METHOD AND DEVICE FOR IMAGE PROCESSING AND COMPUTER- READABLE RECORDING MEDIUM

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a method and a device for image processing which can easily obtain a more adequate image by correcting distortion, and a recording medium which actualizes the method.

SOLUTION: This is an image processor 1 which corrects distortion of images obtained by photographing a subject so that the images overlap with one another and is equipped with a correspondence detection part 21 which detects the correspondence relation between overlap parts in the images obtained by the photography, a reference image setting part 20 which selects an object of distortion correction out of the images, and an image distortion correction part 22 which corrects the distortion of the image set by the reference image setting part 20 according to the correspondence relation detected by the correspondence detection part 21.



BEST AVAILABLE COPY

LEGAL STATUS

[Date of request for examination]	10.02.2005
[Date of sending the examiner's decision of rejection]	
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	
[Date of registration]	
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] The first step which specifies the correspondence relation of the duplication part in said two or more images which are the image-processing approaches which amend distortion of the image photoed from two or more directions as at least a part overlaps to a photographic subject, and were obtained by said photography, The second step which chooses the object which amends said distortion from said two or more images, The image-processing approach characterized by having the third step which amends said distortion of said image chosen at said second step according to said correspondence relation specified in said first step.
[Claim 2] The image-processing approach according to claim 1 which chooses the object of said amendment automatically at said second step according to the size of the field which said photographic subject occupies into said image.
[Claim 3] The image-processing approach according to claim 1 which chooses the object of said amendment automatically at said second step according to the sense of the straight-line-like pattern detected in said image.
[Claim 4] The image-processing approach according to claim 1 which chooses the object of said amendment automatically at said second step according to said correspondence relation specified in said first step.
[Claim 5] The image-processing approach according to claim 1 which chooses the object of said amendment automatically at said second step according to the sense of said photographic subject detected for said every photography.
[Claim 6] It is the image-processing approach which amends distortion of the image photoed from two or more directions so that at least a part might overlap to a photographic subject. The first step which specifies the correspondence relation of the duplication part in said two or more images obtained by said photography, respectively, The second step as which said distortion chooses said fewest images from said two or more images, The image-processing approach characterized by having said image which amended said distortion of said two or more images, respectively, and was chosen in said second step, and the third step to compound according to said correspondence relation specified in said first step.
[Claim 7] A correspondence detection means to detect the correspondence relation of the duplication part in said two or more images which are the image processing systems which amend distortion of the image photoed from two or more directions as at least a part overlaps to a photographic subject, and were obtained by said photography, A selection means by which said distortion chooses said fewest images from said two or more images, The image processing system characterized by having said image which amended said distortion of said two or more images, respectively, and was chosen in said selection means, and an image composition means to compound, according to said correspondence relation detected in said correspondence detection means.
[Claim 8] It is the image processing system which amends distortion of the image photoed from two or more directions so that at least a part might overlap to a photographic subject. A selection means to choose beforehand said image made into the criteria at the time of amending said distortion among said

two or more images to be photoed from now on, A notice means to notify a user of said image photoed next turning into said image made into said criteria according to said selection made by said selection means, A correspondence detection means to detect the correspondence relation of the duplication part between said image made into said criteria acquired by taking a photograph, and said other images, The image processing system characterized by having an amendment means to amend said distortion of said image made into said criteria, according to said correspondence relation detected by said correspondence detection means.

[Claim 9] A correspondence detection means to detect the correspondence relation of the duplication part in said two or more images which are the image processing systems which amend distortion of the image photoed from two or more directions as at least a part overlaps to a photographic subject, and were obtained by said photography, The image processing system characterized by having a selection means to choose the object which amends said distortion from said two or more images, and an amendment means to amend said distortion of said image chosen by said selection means according to said correspondence relation detected by said correspondence detection means.

[Claim 10] Two or more optical means which are the image processing systems which amend distortion of the image photoed from two or more directions as at least a part overlaps to a photographic subject, and photo said photographic subject to coincidence, A selection means to choose said image made into the object of said amendment among said images photoed by said two or more optical means, A correspondence detection means to detect the correspondence relation of the duplication part between said image chosen by said selection means, and said other images, The image processing system characterized by having an amendment means to amend said distortion of said selected image, according to said correspondence relation detected by said correspondence detection means.

[Claim 11] Said selection means is an image processing system according to claim 9 or 10 which chooses the object of said amendment automatically according to the size of the field which said photographic subject occupies into said image.

[Claim 12] Said selection means is an image processing system according to claim 9 or 10 which chooses the object of said amendment automatically according to the sense of the straight-line-like pattern detected in said image.

[Claim 13] Said selection means is an image processing system according to claim 9 which chooses the object of said amendment automatically according to said correspondence relation detected by said correspondence detection means.

[Claim 14] Said selection means is an image processing system according to claim 9 or 10 which chooses the object of said amendment automatically according to the sense of said photographic subject detected for said every photography.

[Claim 15] It is the record medium which recorded the program for a computer to amend distortion of the image photoed from two or more directions so that at least a part might overlap to a photographic subject and in which computer reading is possible. Said program makes the correspondence relation of the duplication part in said two or more images obtained by said photography specify to said computer. The record medium which is characterized by making said distortion of said image which was made to choose the object which amends said distortion and was chosen according to said specified correspondence relation from said two or more images amend and in which computer reading is possible.

[Claim 16] It is the record medium which recorded the program for a computer to amend distortion of the image photoed from two or more directions so that at least a part might overlap to a photographic subject and in which computer reading is possible. Said program makes the correspondence relation of the duplication part in said two or more images obtained by said photography specify to said computer, respectively. The record medium which is characterized by making it compound with said image with which said distortion made said fewest images choose, made said distortion of said two or more images amend according to said correspondence relation as which it was specified, respectively, and was chosen from said two or more images and in which computer reading is possible.

[Translation done.]

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is drawing for explaining the trouble in a Prior art.
[Drawing 2] It is drawing for explaining the image-processing approach and image processing system concerning the gestalt 1 of operation of this invention.
[Drawing 3] It is drawing showing the configuration of the image processing system concerning the gestalt 1 of operation of this invention.
[Drawing 4] It is the perspective view showing the image processing system shown in drawing 3 .
[Drawing 5] It is the flow chart which shows actuation of the image processing system concerning the gestalt 1 of operation of this invention.
[Drawing 6] It is drawing showing the example of a display at the time of the photography in the display shown in drawing 3 .
[Drawing 7] It is drawing showing the layout of the criteria image setting section shown in drawing 3 .
[Drawing 8] It is drawing showing other examples of the image processing system concerning the gestalt 1 of operation of this invention.
[Drawing 9] It is drawing showing the configuration of the correspondence detecting element shown in drawing 3 .
[Drawing 10] It is drawing explaining the actuation of correlation operation part shown in drawing 9 .
[Drawing 11] It is drawing showing the configuration of the image-distortion amendment section shown in drawing 3 .
[Drawing 12] It is drawing 1 explaining the actuation of the image-distortion amendment section shown in drawing 3 .
[Drawing 13] It is drawing explaining the optical system of the image pick-up section shown in drawing 3 .
[Drawing 14] It is drawing explaining the projective transformation by the three-dimension operation part shown in drawing 11 .
[Drawing 15] It is drawing 2 explaining the actuation of the image-distortion amendment section shown in drawing 3 .
[Drawing 16] It is drawing 1 explaining the actuation of the parameter calculation section shown in drawing 11 .
[Drawing 17] It is drawing 2 explaining the actuation of the parameter calculation section shown in drawing 11 .
[Drawing 18] It is drawing for explaining the image-processing approach and image processing system concerning the gestalt 2 of operation of this invention.
[Drawing 19] It is drawing showing the configuration of the image processing system concerning the gestalt 2 of operation of this invention.
[Drawing 20] It is the flow chart which shows actuation of the image processing system concerning the gestalt 2 of operation of this invention.
[Drawing 21] It is drawing showing the configuration of the image composition section shown in

drawing 19 .
[Drawing 22] It is drawing showing the configuration of the image processing system concerning the gestalt 3 of operation of this invention.
[Drawing 23] It is the flow chart which shows actuation of the image processing system concerning the gestalt 3 of operation of this invention.
[Drawing 24] It is drawing explaining a setup of the criteria image to the criteria image setting section shown in drawing 22 .
[Drawing 25] It is drawing explaining the actuation of the notice section shown in drawing 22 .
[Drawing 26] It is drawing showing the configuration of the image processing system concerning the gestalt 4 of operation of this invention.
[Drawing 27] It is the flow chart which shows actuation of the image processing system concerning the gestalt 4 of operation of this invention.
[Drawing 28] It is drawing explaining a setup of the criteria image to the criteria image setting section shown in drawing 26 .
[Drawing 29] It is drawing showing the first example of a configuration in the image processing system concerning the gestalt 5 of operation of this invention.
[Drawing 30] It is the flow chart which shows actuation of the image processing system concerning the gestalt 5 of operation of this invention.
[Drawing 31] It is drawing explaining the gate angular dependence in resolution degradation.
[Drawing 32] It is drawing showing the second example of a configuration in the image processing system concerning the gestalt 5 of operation of this invention.
[Drawing 33] It is drawing explaining the Hough conversion used in the image-processing approach concerning the gestalt 5 of operation of this invention.
[Drawing 34] It is drawing showing the third example of a configuration in the image processing system concerning the gestalt 5 of operation of this invention.
[Drawing 35] It is drawing showing the fourth example of a configuration in the image processing system concerning the gestalt 5 of operation of this invention.
[Drawing 36] It is drawing showing the configuration of the flat-surface measurement section shown in drawing 35 .
[Drawing 37] It is drawing showing the configuration of the image processing system concerning the gestalt 6 of operation of this invention.
[Drawing 38] It is the flow chart which shows actuation of the image processing system concerning the gestalt 6 of operation of this invention.
[Drawing 39] It is drawing showing the configuration of the image processing system concerning the gestalt 7 of operation of this invention.
[Drawing 40] It is drawing which was shown in drawing 39 and which changes and explains actuation of the section.
[Drawing 41] It is drawing showing the image processing system concerning the gestalt of operation of this invention, and a record medium.
[Drawing 42] It is drawing showing the computer concerning the gestalt of operation of this invention, and the record medium in which computer reading is possible.
[Description of Notations]
60 1, 2, 6, 8, 40, 50-53, 70 Image processing system
3, 4, 10, IM1-IM3, im1, im2, imj, imk Image
5 Distortion Amendment Image
7 Criteria Image
9 Reference Image
11 41 Image pick-up section
11A, 11B Optical system
12 Signal-Processing Section
13 Memory Control Section

14 Main Control Section
15 Frame Memory
16 Interface (I/F)
17 Display
18 Enternal Memory Section
19 Photography Mode Setting Section
20 Criteria Image Setting Section
21 Correspondence Detecting Element
22 Image-Distortion Amendment Section
23 Photographic Subject Field Decision Section
24 Image Composition Section
25 Photographic Subject Field Judging Section
26 Notice Section
27 Criteria Image Automatic Selection Section
28 Straight-Line-like Pattern Detecting Element
29 Flat-Surface Measurement Section
30 Image Side
31 Plane of Projection-ed
32 Image Pick-up Side
33 Device-Coordinate System
35 Photographic Subject Image
45 Change Section
101 Electric Power Switch
102 Shutter
103 Finder
104 Photography Mode Setting Key
111 Lens
112 Drawing
113 Shutter
114 Optoelectric Transducer
115 Pretreatment Section
201 Above Scrolling Key
202 Down Scrolling Key
203 Decision Key
204 Cursor Key
211 Focus Setting Section
212 Correlation Operation Part
213 Focus
215,216 Correlation aperture
217 Corresponding Points
221 Three-Dimension Operation Part
222 Parameter Calculation Section
223 Coordinate Transformation Section
224 Image Side
231 Projective-Transformation Calculation Section
232 Coordinate Transformation Section
241 Finder
242 Indicator
271 Spot Light Source
271a Light source
271b Scan mirror

271c Mechanical component
272 Photo Detector
273 Three-Dimension Coordinate Calculation Section
274 Flat-Surface Calculation Section
301 Record Medium
302 CD-ROM
PL Photographic subject side
PC Personal computer (personal computer)
D1-D3, d1, d2, dj, dk Direction
IMA, IMB, IMC Synthetic image

[Translation done.]

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the record medium in which computer reading for realizing the image-processing approach, the image processing system, and this image-processing approach for not being based on a photography condition but obtaining a proper image in more detail about the image-processing approach, an image processing system, and a record medium is possible.
[0002]
[Description of the Prior Art] It will be necessary to also diversify the state of business with the rapid advance of a computer network, and to acquire important information quickly on all aspects of affairs. In connection with it, the demand to inputting goods required for business and document information simple and with high definition everywhere, making full use of the input device of a pocket mold is increasing. Especially, the application that it will utilize as electronic intelligence effective in work or amusement also came to be seen by performing processing and processing to the photoed image with rapid spread and its raise in resolving of a digital still camera.
[0003] Although the distortion of an image (this is also called "gate distortion".) arises as the first typical application when photoing photographic subject sides, such as A4 space and a large-sized poster, and an image pick-up side and a photographic subject side take a photograph in the condition which is not parallel, there is a technique of raising the readability of the document image information acquired by amending this. Here, in the image which wants to amend "gate distortion", it is required that the range of the request of a photographic subject should be copied. That is, it is necessary to photo at least one in the image of two or more sheets which the user photoed so that the range of the request of a photographic subject may be included. Therefore, the interface (I/F) which can choose the object which amends gate distortion among the photoed images of two or more sheets, and an interface to which suitable cautions are urged to a user at the time of photography are desired.
[0004] Moreover, there are some which create the synthetic image of one sheet by carrying out division photography of the pattern drawn on the space information and the panels of a large area, such as a newspaper, or a wall by the portable picture input device as the second application, and sticking the obtained image of two or more sheets. That is, although the resolution of a digital camera is improving in recent years with the increment in the number of pixels of the image sensor represented by CCD (Charge Coupled Device), photoing the photographic subject which has a pattern fine as mentioned above, i.e., the photographic subject containing a high frequency component, and electronizing runs short of resolution still more. Therefore, by sticking an image, a highly minute image is created in false and the approach of compensating the lack of resolution of a digital camera is made.
[0005] When a photographic subject can regard it as a plane, a geometric correction type like affine transformation or projective transformation is used, it is the technique which sticks the image which carried out division photography of some photographic subjects, and such an application changes the photographic subject image of each division image into how the photographic subject in the image used as criteria appears, and sticks. In addition, the outline of such a technique is indicated by reference

"computer vision-technical criticism and future view -" (new technical communique SHONZU besides Takashi Matsuyama).
[0006] However, in such an application, when it instigates in a photographic subject image in the image used as criteria and distortion has arisen, it instigates also in the stuck synthetic image and there is a problem that distortion will be included. That is, the magnitude of the gate distortion in the synthetic image generated changes by on the basis of which image lamination is performed among two or more images which took a photograph in division and were obtained. It explains referring to drawing 1 about this problem.
[0007] If these three images are stuck on the basis of the image IM 1 photoed and obtained from left slant to the photographic subject side PL when a certain photographic subject side PL is photoed from three ways D1-D3 and images IM1-IM3 are obtained, respectively as shown in drawing 1 (a) for example, the synthetic image IMA as shown in drawing 1 (b) will be obtained. Moreover, if it sticks similarly on the basis of the photoed image IM 2 from a transverse plane mostly, the synthetic image IMB as shown in drawing 1 (c) will be obtained. Here, as shown in drawing 1 (b) and drawing 1 (c), both the above-mentioned composition images IMA and IMB differ in the magnitude of gate distortion greatly.
[0008] Therefore, since a photograph is wanted to carry out the right pair of at least one in the photoed image of two or more sheets to the photographic subject side PL mostly, and to be taken, in case it is lamination among the photoed images of two or more sheets, when photoing the interface which chooses the image made into criteria, and the image used as the criteria of the lamination, an interface which demands cautions from a user is desired.
[0009]
[Problem(s) to be Solved by the Invention] This invention is made in view of an above-mentioned point, and aims at offering the record medium in which computer reading for realizing the image-processing approach, the image processing system, and this image-processing approach for amending distortion and obtaining a more proper image easily is possible.
[0010]
[Means for Solving the Problem] The above-mentioned purpose is the image-processing approach which amends distortion of the image photoed from two or more directions so that at least a part might overlap to a photographic subject. The first step which specifies the correspondence relation of the duplication part in two or more images obtained by photography, The second step which chooses the object which amends distortion from two or more images, It is attained by offering the image-processing approach characterized by having the third step which amends distortion of the image chosen at the second step according to the correspondence relation specified in the first step. Since the object which amends distortion is chosen according to such a means, in order to obtain a proper image, the optimal image can be made applicable to amendment.
[0011] You may make it choose the object of amendment automatically at the second step here according to the size of the field which a photographic subject occupies into an image. According to such a means, the paintings-and-calligraphic-works amount of information needed can amend distortion of the most abundant images automatically.
[0012] Moreover, you may make it choose the object of amendment automatically at the second step according to the sense of the straight-line-like pattern detected in an image. According to such a means, the image photoed from the location which carried out the right pair to the photographic subject mostly can be automatically made applicable to amendment.
[0013] Moreover, at the second step, if the object of amendment is automatically chosen according to the correspondence relation specified in the first step, high amendment of precision can be performed certainly.
[0014] Moreover, at the second step, if the object of amendment is automatically chosen according to the sense of the photographic subject detected for every photography, the image photoed from the location which carried out the right pair mostly to the photographic subject can be automatically made applicable to amendment.

[0015] Moreover, the purpose of this invention is the image-processing approach which amends distortion of the image photoed from two or more directions so that at least a part might overlap to a photographic subject. The first step which specifies the correspondence relation of the duplication part in two or more images obtained by photography, respectively, The second step as which distortion chooses fewest images from two or more images, According to the correspondence relation specified in the first step, distortion of two or more images is amended, respectively, and it is attained by offering the image-processing approach characterized by having the image chosen in the second step, and the third step to compound. According to such a means, since a synthetic image is generated on the basis of an image with least distortion, a more proper synthetic image can be obtained.
[0016] Moreover, the purpose of this invention is an image processing system which amends distortion of the image photoed from two or more directions so that at least a part might overlap to a photographic subject. A correspondence detection means to detect the correspondence relation of the duplication part in two or more images obtained by photography, It responds to the correspondence relation by which distortion was detected in a selection means to choose fewest images, and the correspondence detection means, out of two or more images. Distortion of two or more images is amended, respectively, and it is attained by offering the image processing system characterized by having the image chosen in the selection means, and an image composition means to compound.
[0017] Moreover, the purpose of this invention is an image processing system which amends distortion of the image photoed from two or more directions so that at least a part might overlap to a photographic subject. A selection means to choose beforehand the image made into the criteria at the time of amending distortion among two or more images to be photoed from now on, A notice means to notify a user of the image photoed next turning into an image made into criteria according to the selection made by the selection means, A correspondence detection means to detect the correspondence relation of the duplication part between the image made into the criteria acquired by taking a photograph, and other images, It is attained by offering the image processing system characterized by having an amendment means to amend the distortion of an image made into criteria, according to the correspondence relation detected by the correspondence detection means. According to such a means, in the photography of an image made into the criteria at the time of amending distortion, attention can be called to a user.
[0018] Moreover, the purpose of this invention is an image processing system which amends distortion of the image photoed from two or more directions so that at least a part might overlap to a photographic subject. A correspondence detection means to detect the correspondence relation of the duplication part in two or more images obtained by photography, It is attained by offering the image processing system characterized by having a selection means to choose the object which amends distortion from two or more images, and an amendment means to amend distortion of the image chosen by the selection means according to the correspondence relation detected by the correspondence detection means.
[0019] Moreover, two or more optical means which the purpose of this invention is an image processing system which amends distortion of the image photoed from two or more directions as at least a part overlaps to a photographic subject, and photo a photographic subject to coincidence, A selection means to choose the image made into the object of amendment among the images photoed by two or more optical means, A correspondence detection means to detect the correspondence relation of the duplication part between the image chosen by the selection means, and other images, It is attained by offering the image processing system characterized by having an amendment means to amend distortion of the selected image, according to the correspondence relation detected by the correspondence detection means. Since two or more photographic subject images once photoed by photography from two or more directions can be obtained according to such a means, the count of photography needed in order to amend distortion can be reduced.
[0020] Here, a selection means shall choose the object of amendment automatically according to the sense of the straight-line-like pattern which shall choose the object of amendment automatically according to the size of the field which a photographic subject occupies into an image, or is detected in an image. Moreover, a selection means is good also as what chooses the object of amendment automatically according to the sense of the photographic subject which should choose the object of

amendment automatically according to the correspondence relation detected by the correspondence detection means, or was detected for every photography.
[0021] Moreover, the purpose of this invention is a record medium which recorded the program for a computer to amend distortion of the image photoed from two or more directions so that at least a part might overlap to a photographic subject and in which computer reading is possible. This program makes the correspondence relation of the duplication part in two or more images obtained by photography specify to a computer. It is attained by offering the record medium which is characterized by making distortion of the image which was made to choose the object which amends distortion and was chosen according to the specified correspondence relation from two or more images amend and in which computer reading is possible. According to such a means, in order to obtain a proper image, the optimal image can be easily made applicable to amendment.
[0022] Moreover, the purpose of this invention is a record medium which recorded the program for a computer to amend distortion of the image photoed from two or more directions so that at least a part might overlap to a photographic subject and in which computer reading is possible. This program makes the correspondence relation of the duplication part in two or more images obtained by photography specify to a computer, respectively. It is attained by offering the record medium which is characterized by making it compound with the image which was made to amend distortion of two or more images, respectively, and was chosen according to the correspondence relation as which distortion made fewest images choose as and it was specified from two or more images and in which computer reading is possible. According to such a means, a more proper synthetic image can be obtained easily.
[0023]
[Embodiment of the Invention] The gestalt of operation of this invention is explained in detail with reference to a drawing below. In addition, a same-among drawing sign shows the same or a considerable part.
[Gestalt 1 of operation] drawing 2 is drawing for explaining the image-processing approach and image processing system concerning the gestalt 1 of operation of this invention. As the gestalt of this operation is shown to drawing 2 by here, the images 3 and 4 of two sheets are photoed so that a part of photographic subject side [at least] PL may overlap with an image processing system 1, and it is explained by the example of amending the gate distortion by either 3, for example, an image, among the images 3 and 4 of these two sheets, and finally obtaining the distortion amendment image 5.
[0024] Drawing 3 is drawing showing the configuration of the image processing system 1 concerning the gestalt 1 of operation of this invention. As shown in drawing 3 , an image processing system 1 is equipped with the image pick-up section 11, the signal-processing section 12, the memory control section 13, the main control section 14, a frame memory 15, an interface 16, a display 17, the enternal memory section 18, the photography mode setting section 19, the criteria image setting section 20, the correspondence detecting element 21, and the image-distortion amendment section 22. And the image pick-up section 11 contains a lens 111, diaphragm 112, a shutter 113, an optoelectric transducer 114, and the pretreatment section 115.
[0025] Here, the signal-processing section 12 is connected to the pretreatment section 115, the memory control section 13, the main control section 14, and an interface 16. Moreover, the memory control section 13 is further connected to a frame memory 15 and the criteria image setting section 20. The main control section 14 is further connected to the memory control section 13, the photography mode setting section 19, and the criteria image setting section 20.
[0026] Moreover, a frame memory 15 is connected to the memory control section 13, the correspondence detecting element 21, and the image-distortion amendment section 22. Moreover, an interface 16 is further connected to a display 17 and the enternal memory section 18. And the criteria image setting section 20 is further connected to the image-distortion amendment section 22. Moreover, the correspondence detecting element 21 is further connected to the image-distortion amendment section 22.
[0027] On the other hand, in the image pick-up section 11, it extracts as a lens 111, and 112, a shutter 113, and an optoelectric transducer 114 are arranged on an optical axis at this order, and an optoelectric

transducer 114 is connected to the pretreatment section 115.
[0028] In the above, photography mode is changed by the photography mode setting section 19, and the image which instigates in the criteria image setting section 20, and amends distortion is set up. Moreover, the correspondence detecting element 21 extracts the focus and corresponding points between both images in two images with which at least the part overlapped mutually. And the image-distortion amendment section 22 amends the gate distortion in the photoed image according to the signal supplied from the correspondence detecting element 21. In addition, a setup of the criteria image in the above, actuation of the correspondence detecting element 21, and amendment of gate distortion are explained in detail later.
[0029] Moreover, CCD is used for the optoelectric transducer 114 of the image pick-up section 11. Moreover, the pretreatment section 115 is equipped with the analog signal processing section and the analog-digital converter (A/D converter) which consist of pre amplifier, an automatic gain control circuit (Auto Gain Control-AGC), etc., and after pretreatment of magnification, a clamp, etc. is performed to the analog video signal outputted from the optoelectric transducer 114, the above-mentioned analog video signal is changed into a digital video signal.
[0030] Moreover, the signal-processing section 12 is constituted by the digital signal processor (DSP processor) etc., and performs various image processings, such as color separation, white balance adjustment, and gamma amendment, to the digital video signal acquired in the image pick-up section 11. Moreover, the memory control section 13 stores in a frame memory 15 the picture signal processed by doing in this way, or reads the picture signal conversely stored in the frame memory 15. Moreover, the main control section 14 is constituted by the microcomputer etc. Moreover, a frame memory 15 stores the image of at least two sheets, and, generally semiconductor memory, such as VRAM, SRAM, and DRAM, is used.
[0031] Here, the picture signal read from the frame memory 15 is saved in the enternal memory section 18 through an interface 16, after signal processing, such as picture compression, is performed in the signal-processing section 12. Reading and this enternal memory section 18 write various signals, such as a picture signal supplied through an interface 16, and is constituted by IC memory card, the magneto-optic disk, etc. As the enternal memory section 18, if a modem card and an ISDN card are used, a picture signal can also be transmitted to the record medium of a direct remote place via a network here.
[0032] Moreover, a picture signal is transmitted to the signal-processing section 12 through an interface 16, and read-out of the picture signal conversely recorded on the enternal memory section 18 is performed by giving image expanding in the signal-processing section 12. On the other hand, the display of the picture signal read from the enternal memory section 18 and a frame memory 15 is performed by transmitting to a display 17 through an interface 16, after performing signal processing, such as digital to analog (D/A conversion) and magnification, to a picture signal in the signal-processing section 12. A display 17 consists of liquid crystal displays which displayed the image according to the picture signal supplied through the interface 16, for example, were installed in the case of an image processing system 1 here.
[0033] Drawing 4 is the perspective view showing the image processing system shown in drawing 3 . As shown in drawing 4 , the image processing system 1 concerning the gestalt of this operation contains an electric power switch 101, a shutter 102, a finder 103, the photography mode setting key 104 for setting photography mode as the photography mode setting section 19, the above scrolling key 201 for scrolling upward the image projected on the display 17, the down scrolling key 202 for scrolling downward the image projected on the display 17, and the decision key 203.
[0034] It explains referring to the flow chart shown in drawing 4 and drawing 5 in actuation of the image processing system which has the above configurations below. First, an electric power switch 101 is changed, an image processing system 1 is started, and photography mode is chosen. Here, the above-mentioned photography mode consists of the normal mode which takes the usual snapshot, and gate amendment mode which generates the image which amended the gate distortion of the photoed image. And selection in this photography mode is made when a user operates the photography mode setting key 104. In addition, as the photography mode setting section 19, the photography mode setting key 104 is

formed in the body of an image processing system 1. However, the photography mode setting section 19 may consist of hardware or software etc. which are formed separately from a body.
[0035] And if it is judged whether it instigates in step S1 and amendment mode is chosen, and gate amendment mode is not chosen but the normal mode is chosen as shown in drawing 5 , it will progress to step S10 and the snapshot of a desired photographic subject will be taken by the user.
[0036] On the other hand, if it instigates in step S1 and amendment mode is chosen, it will progress to step S2. And a user photos at least two photographic subject sides PL by the image pick-up section 11, and a photographic subject image is incorporated by the image processing system 1. In addition, each image needs to be photoed so that some photographic subject images may overlap mutually at this time.
[0037] Next, it is judged whether the input of a photographic subject image was completed in step S3, when having not ended, it returns to step S2, and the input of a photographic subject image is continued further. On the other hand, when the input of a photographic subject image is ended with directions of the photography termination by the user, it progresses to step S4. In addition, the above-mentioned directions are made by pressing the photography mode setting key 104 once again, and changing to the normal mode, and also they may form the switch for directing photography termination separately.
[0038] Moreover, as shown during photography at drawing 6 , the screen overlay of the present photography number of sheets, such as "the 1st sheet", and the photography termination approaches, such as "ending, if a photography mode setting key is pressed", may be carried out to a display 17.
[0039] And although the actuation which instigates below to step S4 and amends distortion is started after photography is completed as mentioned above, it chooses the gate distortion of which image is first amended in step S4, and this image is set up. In addition, the image chosen at this time is also called a "criteria image" to below. And a setup of this criteria image is performed in the criteria image setting section 20. The configuration and actuation of the criteria image setting section 20 are explained in detail below.
[0040] Drawing 7 is drawing showing the layout of the criteria image setting section 20 shown in drawing 3 . As shown in drawing 7 , the criteria image setting section 20 contains the above scrolling key 201, and the down scrolling key 202 and the decision key 203. And as shown in drawing 7 , when directions of photography termination are made by the user in step S3, in a display 17, an overlay indication of the alphabetic character "criteria image setup" is given, and it points so that a criteria image may be chosen as a user.
[0041] Then, the above scrolling key 201 and the down scrolling key 202 are operated by the user, and it is displayed, the image photoed in the above-mentioned step S2 changing one by one. In addition, the image photoed after [of the image by which it is indicated by current] one is displayed by pressing the above scrolling key 201 by displaying the image photoed before [of the image by which it is indicated by current] one, and pressing the down scrolling key 202. And if the decision key 203 is pressed in the condition that the image chosen as a criteria image is displayed on the display 17, the image currently displayed at the time will be determined as a criteria image.
[0042] And the image with the smallest possible angle that crossed to the field where the photographic subject side PL is the largest, and has been reflected to it in two or more photoed images as the above-mentioned criteria image, and is made to the photographic subject side of the image pick-up side at the time of photography is chosen by the user.
[0043] Here, choosing automatically the image optimal as the object which calculates a photographic subject field and the above-mentioned tilt angle inside equipment, instigates according to the result of this count, and amends distortion, i.e., a criteria image, is also considered. Drawing 8 is drawing showing the configuration of the image processing system 2 which realizes such actuation. As shown in drawing 8 , an image processing system 2 is equipped with the photographic subject field decision section 23 instead of the criteria image setting section 20 contained in the image processing system 1 shown in drawing 3 .
[0044] And as the above-mentioned photographic subject field decision section 23 performs processing which detects the field which a photographic subject occupies in the photoed image, for example, it is indicated by reference "processing of an image and recognition" (Takeshi Akoin and Tomoharu Nagao

collaboration, Shokodo) (a) How to cluster on an image like a field grown method or a field split plot experiment, (b) The field division approaches using the edge in images, such as the approach of clustering on feature spaces, such as field division by the histogram, and (c) profile line tracking, such as an approach and the (d) texture analysis, are applied. However, when a photographic subject side is a rectangle, the field of a photographic subject is determined as a meaning by carrying out the external input of the top-most-vertices coordinate of the four corners of the photographic subject on an image.
[0045] Thus, the data in which the field of the photographic subject acquired in the photographic subject field decision section 23 is shown are supplied to the image-distortion amendment section 22, and an image with this largest field is chosen in the image-distortion amendment section 22. Furthermore, in the image-distortion amendment section 22, since the include angle made to the photographic subject side PL of an image pick-up side is calculated, when there are two or more images with the above-mentioned largest field (i.e., when there are two or more images with which for example, the whole photographic subject side is reflected), finally an image with the above-mentioned smallest include angle is chosen as a criteria image, so that it may explain in full detail below.
[0046] In addition, the above functions which choose a criteria image automatically are applicable similarly in the gestalt of which [of the following] operation.
[0047] Next, it progresses to step S5, the focus is detected in the criteria image determined as mentioned above, and the corresponding points which show the same part as the above-mentioned focus in the image (it is also called a "reference image" to below.) which overlaps in these some criteria images [at least] are detected. Detection of such the focus and corresponding points is performed by the correspondence detecting element 21 shown in drawing 3 . Then, the configuration and actuation of this correspondence detecting element 21 are explained in detail below.
[0048] The correspondence detecting element 21 detects the photoed same part in the image with the field which overlapped mutually as mentioned above of two sheets. And the approach which used the correlation operation here is explained.
[0049] Drawing 9 is drawing showing the configuration of the correspondence detecting element 21 shown in drawing 3 . As shown in drawing 9 , the correspondence detecting element 21 is equipped with the focus setting section 211 connected to the frame memory 15, and the correlation operation part 212 connected to the focus setting section 211 and a frame memory 15. In addition, the criteria image and the reference image are stored in the frame memory 15 shown in drawing 3 .
[0050] After the focus setting section 211 determines the location of the focus in a criteria image, it extracts the shade pattern of x (2N+1) (2P+1) individual centering on the focus, and creates the data of the field called a correlation aperture here. In addition, the location of the above-mentioned focus is determined by extracting the part where the concentration pattern of an image is characteristic like an angle (corner).
[0051] Moreover, the correlation operation part 212 detects the part which is mostly in agreement with the shade pattern of the correlation aperture created based on the criteria image by performing a correlation operation in a reference image, and determines this as corresponding points. An example which detects corresponding points by block matching by the correlation operation here is explained referring to drawing 10 .
[0052] As shown in drawing 10 , in block matching of the correlation aperture 215,216 which consists of a shade pattern of x (2N+1) (2P+1) individual, the cross-correlation value Si of the i-th focus 213 which has a coordinate in the criteria image 7 (xi0, yi0), and the corresponding points 217 which have a coordinate in the reference image 9 (xi0+dxi, yi0+dyi) is calculated by the degree type.
[0053]
[Equation 1]

$$S_i = \frac{1}{K}\sum_{x=-N}^{N}\sum_{y=-P}^{P}\left[I_s(x_{i0}+x, y_{i0}+y) - \overline{I_s(x_{i0}, y_{i0})}\right] \times \left[I_r(x_{i0}+dx_i+x, y_{i0}+dy_i+y) - \overline{I_r(x_{i0}+dx_i, y_{i0}+dy_i)}\right] \quad (1)$$

In addition, in the above-mentioned formula (1), Is (x y) shows concentration [in / for the concentration in the coordinate point (x y) of the criteria image 7 / in an example and Ir (x y) / the coordinate point (x y) of the reference image 9]. Moreover, Is (x y) shows the average concentration in the pattern of x (2N+1) (2P+1) individual centering on the coordinate point in the /correlation aperture 215 in the criteria image 7 (x y). Ir (x y) shows the average concentration in the pattern of x (2N+1) (2P+1) individual centering on the coordinate point in the /correlation aperture 216 in the reference image 9 (x y). Moreover, K shows a constant.

[0054] And the corresponding points 217 in the reference image 9 are called for by searching for the point which is beyond the threshold as which the maximum of the cross-correlation value Si was beforehand determined by the above-mentioned formula (1) to each focus 213. In addition, if the maximum of the cross-correlation value Si becomes below a threshold, corresponding points shall not exist.

[0055] Thus, after detection of the focus and corresponding points is completed, while calculating the parameter which amends the gate distortion of the criteria image 7 in step S6 shown in drawing 5 , the image which amended the gate distortion of an image based on this parameter in step S7 is created, and actuation is ended. In addition, the image which amended a "distortion amendment parameter" and gate distortion for the above-mentioned parameter below, respectively is also called "distortion amendment image."

[0056] And count of the above-mentioned distortion amendment parameter and generation of a distortion amendment image are performed by the image-distortion amendment section 22. The configuration and actuation of this image-distortion amendment section 22 are explained in detail below.

[0057] The image-distortion amendment section 22 amends gate distortion by changing into the image which photoed the photographic subject side from the transverse plane using the relation of the focus and corresponding points which the correspondence detecting element 21 detected. And the configuration of this image-distortion amendment section 22 is shown in drawing 11 . As shown in drawing 11 , the image-distortion amendment section 22 contains the three-dimension operation part 221, the parameter calculation section 222, and the coordinate transformation section 223. Here, the three-dimension operation part 221 is connected to the correspondence detecting element 21 and the criteria image setting section 20, and the parameter calculation section 222 is connected to the three-dimension operation part 221. Moreover, the coordinate transformation section 223 is connected to the parameter calculation section 222, a frame memory 15, and the criteria image setting section 20.

[0058] Actuation of the image-distortion amendment section 22 is explained below. In addition, as shown below at drawing 12 , while the criteria image 7 and the reference image 9 are photoed to the photographic subject side PL As the optical system of the image pick-up section 11 is shown in drawing 13 , it is related with a x axis. Facing the right of the image side 224 Forward, The sense which goes facing down of the image side 224 to the image side 224 about the z-axis of forward and the direction of an optical axis about the y-axis from the zero O which is the optical axis of the image pick-up section 11 Forward, The focal distance of this optical system explains as an example the case where it considers as the central projection model (perspectiveprojection model) set to f.

[0059] The three-dimension operation part 221 shown in drawing 11 computes the following three-dimension parameters with the relation between the above-mentioned focus 213 and corresponding points 217. That is, normal vector n which shows the sense of the translational-motion vector t which shows change of the location of the image pick-up section 11 at the time of the reference image photography based on the time of the rotation matrix R which shows change of the sense of the image pick-up section 11 at the time of the reference image photography based on the time of the criteria image photography shown in drawing 12 , and criteria image photography, and the photographic subject side PL is computed. And the method of asking for these three three-dimension parameters {R, t, n} is mainly made into two of the followings.

[0060] that is, as a primary method, by the group of the eight or more focus and corresponding points, after calculating the location of the camera at the time of each image photography, a posture, and the

three-dimension coordinate of each corresponding points, it assumes that a photographic subject is a flat surface, and there is a method of applying this profit **** three-dimension coordinate to one flat surface.

[0061] Moreover, as the second approach, from the group of the four or more focus and corresponding points, a projective-transformation matrix (homography matrix) is calculated and there is the approach of computing the location of the camera at the time of each image photography and the sense of a posture and a photographic subject side according to the acquired projective-transformation matrix.

[0062] Here, although the above-mentioned primary method is a general-purpose movement stereoscopic vision technique and a meaning is asked for the above-mentioned parameter {R, t, n} by the linearity operation, the detail is recorded on the common reference (for example, "three-dimension vision" **** and crossing Saburo collaboration, KYORITSU SHUPPAN) about three-dimension measurement or a computer vision. On the other hand, the second approach of the above computes the sense of a camera, and the sense of a photographic subject side, after asking for the coordinate transformation equation (projective-transformation matrix) materialized under the constraint that a photographic subject is a flat surface. And although the three-dimension operation part 221 can, needless to say, take any [the above-mentioned first and / second] approach, it explains the actuation based on the second approach here.

[0063] The calculation procedure of a projective-transformation matrix is explained in detail first. Here, it points out obtaining the image 10 changed into the image obtained when the photographic subject image reflected to the criteria image 7 is photoed from the same direction as the reference image 9, as indicated in drawing 14 as the projective transformation from a criteria image to a reference image. And when this projective transformation is expressed with a formula and the point (xs, ys) in a criteria image and the point (xr, yr) in a reference image have a correspondence relation, it becomes like a degree type.

[0064]

[Equation 2]

$$\begin{cases} x_r = \dfrac{b_1 x_s + b_2 y_s + b_3}{b_7 x_s + b_8 y_s + 1} \\ y_r = \dfrac{b_4 x_s + b_5 y_s + b_6}{b_7 x_s + b_8 y_s + 1} \end{cases} \quad (2)$$

And they are eight unknowns b1-b8 in the above-mentioned formula (2) [0065]

[Equation 3]

$$B = \begin{bmatrix} b_1 & b_2 & b_3 \\ b_4 & b_5 & b_6 \\ b_7 & b_8 & 1 \end{bmatrix} \quad (3)$$

It collects as a matrix B and this is called a projective-transformation matrix. In order to search for this projective-transformation matrix B, 4 or more sets of groups of the focus whose coordinates in a criteria image are (xsi, ysi), and the corresponding points (i= 1, --, N;N>=4) whose coordinates in a reference image are (xri, yri) are used. Here, although what is necessary is to substitute a coordinate (xsi, ysi) and a coordinate (xri, yri) to the above-mentioned formula (2), and just to calculate the solution of b1-b8, since a formula (2) is not materialized according to errors, such as a noise superimposed on an image in fact, it will solve using the least square operation shown below.

[0066]

[Equation 4]

$$\sum_{i=1}^{N}\left[\left(\frac{b_1 x_{si} + b_2 y_{si} + b_3}{b_7 x_{si} + b_8 y_{si} + 1} - x_{ri}\right)^2 + \left(\frac{b_4 x_{si} + b_5 y_{si} + b_6}{b_7 x_{si} + b_8 y_{si} + 1} - y_{ri}\right)^2\right] \rightarrow \min. \quad (4)$$

And the above-mentioned formula (4) deforms as follows.
[0067]
[Equation 5]

$$\sum_{i=1}^{N} [\{b_1 x_{si} + b_2 y_{si} + b_3 - (b_7 x_{si} + b_8 y_{si} + 1)x_{ri}\}^2 + \{b_4 x_{si} + b_5 y_{si} + b_6 - (b_7 x_{si} + b_8 y_{si} + 1)y_{ri}\}^2] \rightarrow \min. \quad (5)$$

Use of the constraint that the value of the derivative obtained by carrying out strange differential of the left part of the above-mentioned equation (5) by b1-b8, respectively is set to 0 calculates b1-b8 by solving a simultaneous equation. That is, the projective-transformation matrix B can be searched for by the easy linearity operation using the group matched the account of a top.
[0068] Then, the procedure of asking for a three-dimension parameter {R, t, n} from the projective-transformation matrix B is explained. It is normal vector n of a photographic subject side [0069]
[Equation 6]

$$n = \begin{bmatrix} a \\ b \\ c \end{bmatrix} \qquad (a^2 + b^2 + c^2 = 1,\ c > 0) \quad (6)$$

It is the equation of the photographic subject [carry out and] side on the basis of the time of criteria image photography [0070]
[Equation 7]

$$(n, r) + d = 0 \quad (7)$$

Here, |d| shows the distance from the zero to the photographic subject side PL, and is r=[x y z] T. It sets. Moreover, a formula (2) is rewritten like a degree type using a focal distance f.
[0071]
[Equation 8]

$$\begin{cases} x_r = f \dfrac{H_{11} x_s + H_{21} y_s + H_{31} f}{H_{13} x_s + H_{23} y_s + H_{33} f} \\ y_r = f \dfrac{H_{12} x_s + H_{22} y_s + H_{32} f}{H_{13} x_s + H_{23} y_s + H_{33} f} \end{cases} \quad (8)$$

Furthermore, a formula (8) is [0072].
[Equation 9]

$$\begin{bmatrix} x_r \\ y_r \\ f \end{bmatrix} = s \begin{bmatrix} H_{11} & H_{21} & H_{31} \\ H_{12} & H_{22} & H_{32} \\ H_{13} & H_{23} & H_{33} \end{bmatrix} \begin{bmatrix} x_s \\ y_s \\ f \end{bmatrix} = s H^T \begin{bmatrix} x_s \\ y_s \\ f \end{bmatrix} \quad (9)$$

It deforms. However, [0073]
[Equation 10]

$$s = \frac{1}{H_{13} x_s + H_{23} y_s + H_{33} f} \quad (10)$$

It comes out. At this time, the matrix H of a formula (9) and the relation with a parameter {R, t, n, d} become like a degree type.

[0074]

[Equation 11]

$$H^T = s' R^T \left(dI + t n^T \right) \tag{11}$$

However, s' is a constant and each element of Matrix H has one times the degree of freedom of a scale. Moreover, a degree type can perform conversion in procession H of a formula (9) from the projective-transformation matrix B of a formula (3).

[0075]

[Equation 12]

$$H^T = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & f \end{bmatrix} B \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1/f \end{bmatrix} = \begin{bmatrix} b_1 & b_2 & b_3/f \\ b_4 & b_5 & b_6/f \\ f b_7 & f b_8 & 1 \end{bmatrix} \tag{12}$$

The procedure of asking below for a parameter {R, t, n, d} stranger than Matrix H is shown. However, since it is unfixed, Variable d and the scale of the magnitude of the translational-motion vector t showing distance with a photographic subject side are [0076].

[Equation 13]

$$\|t\| = 1 \tag{13}$$

It assumes. Here, although the detail is describing in reference "mathematical principle of image comprehension-three-dimension recognition -" (Ken-ichi Kaneya work, Morikita Shuppan), the computation which derives the solution {R, t, n, d} to is as follows when the result is summarized.
(i) It is made to be set to det[H] =1, applying the suitable constant for each element of the matrix H of a formula (9). (ii) Characteristic value of a symmetric matrix HHT is set to sigma12, sigma22, and sigma32, the corresponding characteristic vectors u1, u2, and u3 are mutually intersected perpendicularly, and it takes to the unit vector which makes a right-hand system in this order. However, sigma1>=sigma2>=sigma3> It is referred to as 0. (iii) A movement parameter will be [0077] if it becomes sigma1=sigma2=sigma3.

[Equation 14]

$$t = 0, \quad R = H \tag{14}$$

It comes out, and it is and the parameter {n, d} of a photographic subject side is unfixed. Otherwise, 2 sets of solutions are acquired as follows. (iv) The parameter {n, d} of a photographic subject side becomes settled as follows.

[0078]

[Equation 15]

$$n = \frac{\varepsilon}{\sqrt{\sigma_1^2 - \sigma_3^2}} \left(\pm \sqrt{\sigma_1^2 - \sigma_2^2}\, u_1 + \sqrt{\sigma_2^2 - \sigma_3^2}\, u_3 \right) \tag{15}$$

[0079]

[Equation 16]

$$d = -\frac{\sigma_2}{\sigma_1 - \sigma_3} \tag{16}$$

However, it is epsilon= **1, and epsilon is chosen so that it may be set to c> 0. Moreover, (v) unit translational-motion vector t becomes settled as follows.

[0080]

[Equation 17]

$$t=\frac{1}{\sigma_2\sqrt{\sigma_1^2-\sigma_3^2}}\left(\pm\sigma_3\sqrt{\sigma_1^2-\sigma_2^2}u_1-\sigma_1\sqrt{\sigma_2^2-\sigma_3^2}u_3\right)\ \text{(複号同順)} \qquad (17)$$

Moreover, the rotation matrix R becomes settled as follows.

[0081]

[Equation 18]

$$R=\frac{1}{\sigma_2}\left[I-\frac{1}{(n,\ t)+d}nt^T\right]H \qquad (18)$$

Therefore, although two kinds of solutions {R, t, n, d} to are acquired from Matrix B, when the most, a true solution can be distinguished from the drawn value. In addition, although the focal distance f of the image pick-up section 11 is used by intermediate count, the value of a focal distance f can be easily obtained by the approach of memorizing the optical-system parameter of the image pick-up section 11 to an internal memory (not shown). Moreover, if the focal distance of both images is known even when the focal distances of a criteria image and a reference image differ [the focal distance of the optical system of the image pick-up section 11] with adjustable, the above-mentioned three-dimension parameter calculation procedure can be applied as it is, and a focal distance can be detected by the approach of installing an encoder in optical system.

[0082] Next, the parameter calculation section 222 shown in drawing 11 calculates the parameter which amends gate distortion based on relation with the sense of the photographic subject side computed by the image pick-up section 11 and the three-dimension operation part 221 when photoing a photographic subject side. As the gestalt of this operation is shown to drawing 15 by here, the gate distortion of an image is amended by performing projective transformation of projecting the image side 30 containing the photographic subject image which has gate distortion, by using as the plane of projection 31-ed a flat surface parallel to the photographic subject side which the three-dimension operation part 221 computed. The point P1 on the image side 30 is projected on the point P2 on the plane of projection 31-ed here. The count approach of the parameter which amends the above-mentioned gate distortion below is explained.

[0083] First, as shown in drawing 16 , it asks for rotation matrix R' which shows the coordinate transformation which makes the z-axis in the device-coordinate system 33 in agreement with the unit normal vector of the plane of projection 31-ed. In this case, the following relational expression is materialized.

[0084]

[Equation 19]

$$R'\begin{bmatrix}0\\0\\1\end{bmatrix}=\begin{bmatrix}a\\b\\c\end{bmatrix} \qquad (19)$$

And although much rotation matrix R' which fills the above-mentioned formula (9) exists, rotation matrix R' is defined like a degree type here.

[0085]

[Equation 20]

$$R'=R'_yR'_x=\begin{bmatrix}R'_{11}&R'_{12}&R'_{13}\\R'_{21}&R'_{22}&R'_{23}\\R'_{31}&R'_{32}&R'_{33}\end{bmatrix} \qquad (20)$$

However, R'x and R'y are shown as follows here, respectively.

[0086]
[Equation 21]

$$R'_x = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\alpha & -\sin\alpha \\ 0 & \sin\alpha & \cos\alpha \end{bmatrix}, \quad R'_y = \begin{bmatrix} \cos\beta & 0 & \sin\beta \\ 0 & 1 & 0 \\ -\sin\beta & 0 & \cos\beta \end{bmatrix} \tag{21}$$

As shown in drawing 17 , this rotates the device-coordinate system (xyz system of coordinates) 33 in following sequence, and is equivalent to changing into x'y'z' system of coordinates. (i) beta rotation of the device-coordinate system 33 is done only around the y-axis. And let the system of coordinates obtained by this rotation be 1y1zx1 system of coordinates. (ii) Only alpha rotates a device-coordinate system around x1 shaft.
[0087] Here, if a formula (19) and a formula (20) are used, an angle of rotation will be drawn like a degree type.
[0088]
[Equation 22]

$$\alpha = \sin^{-1}(-b) \tag{22}$$

$$\beta = \sin^{-1}\left(\frac{a}{\sqrt{a^2 + c^2}}\right) \tag{23}$$

And matrix R' can be set to a meaning by substituting for a formula (20) and a formula (21) the angle of rotation searched for in this way.
[0089] Next, coordinate transformation of the coordinate on the image side 30 is carried out on the plane of projection 31-ed. That is, let the point P2 which intersects the plane of projection 31-ed when the three-dimension vector p corresponding to the point P1 of the image side 30 is extended be a coordinate after coordinate transformation in drawing 15 . And the three-dimension vector p corresponding to the point P1 on the basis of the device-coordinate system 33 is shown by the degree type.
[0090]
[Equation 23]

$$P = \frac{k}{ax_s + by_s + cf}\begin{bmatrix} x_s \\ y_s \\ f \end{bmatrix} \quad (k > 0) \tag{24}$$

Here, since k is a scaling factor showing the distance from the optical axis o of the image pick-up section 11 to plane of projection-ed, k expresses the magnitude of the distortion amendment image created. moreover -- a three dimension -- a vector -- p -- criteria -- an image -- photography -- the time -- a device coordinate -- a system -- 33 -- criteria -- carrying out -- a point -- P -- one -- having expressed -- a vector -- it is -- although -- this -- rotation -- a matrix -- R -- ' -- using -- a degree -- a type -- like -- coordinate transformation -- carrying out -- things -- an image pick-up -- the section -- 11 -- a photographic subject -- a field -- right -- a pair -- carrying out -- having made -- the time -- a three dimension -- a vector -- p -- ' -- changing -- having .
[0091]
[Equation 24]

$$P' = \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = R'^{-1}P = \frac{k}{ax_s + by_s + cf}\begin{bmatrix} R'_{11} & R'_{21} & R'_{31} \\ R'_{12} & R'_{22} & R'_{32} \\ R'_{13} & R'_{23} & R'_{33} \end{bmatrix}\begin{bmatrix} x_s \\ y_s \\ f \end{bmatrix} \tag{25}$$

Therefore, the image which amended gate distortion is obtained by making the x-coordinate and y-

coordinate of a formula (25) into the coordinate acquired after coordinate transformation. And the parameter which amends the gate distortion of a criteria image using a formula (25) is computable with the above procedures.

[0092] Next, the coordinate transformation section 223 coordinate-transformation-creates a distortion amendment image for a criteria image based on the gate distortion amendment parameter computed by the parameter calculation section 222. The coordinate (xs, ys) before the conversion corresponding to the coordinate after coordinate transformation (X, Y) is calculated based on a formula (25), and, specifically, a interpolation operation determines the pixel value in a coordinate (X, Y) based on a pixel value [/ near the calculated coordinate (xs, ys)]. In addition, what is necessary is just to perform this interpolation operation using the existing approaches, such as a congruence linear interpolation method and B-spline interpolation method.

[0093] As mentioned above, when according to the image processing system concerning the gestalt 1 of operation of this invention a photographic subject side is photoed two or more sheets so that at least parts may overlap mutually, the gate distortion in the image of the photoed arbitration can be amended, and the overview of a more proper photographic subject can be obtained.

[0094] That is, it is sufficient, if there are an image which photoed the whole photographic subject, and an image which photoed some photographic subjects as it is necessary to photo all the range of a photographic subject in no images in the above-mentioned procedure for example, and is shown in drawing 14 . And since the image which photoed the whole photographic subject by the criteria image setting section 20 can be chosen as a criteria image in such a case, the overview of the photographic subject with which gate distortion was amended is generable.

[0095] Moreover, if the number of sheets to photo is limited to two sheets since there should just be a photographic subject image of two sheets at worst in order to generate a distortion amendment image by the above-mentioned approach, count cost which the input of an image and a setup of photography and a criteria image are not only simplified for a user, but detection of memory space, the focus, and corresponding points required in order to memorize an image, and count of a projective-transformation matrix take can be made small.

[Gestalt 2 of operation] drawing 18 is drawing for explaining the image-processing approach and image processing system concerning the gestalt 2 of operation of this invention. As shown in drawing 18 (a), actuation of the image processing system 6 concerning the gestalt of this operation when the static image of the same photographic subject side PL is photoed from two or more directions d1-dk so that it may overlap in some images, respectively is explained.

[0096] Here, as shown in drawing 18 (a), suppose that there is a duplication field, respectively by taking a photograph from Direction Dn by Hazama of Image imj and Image im (j+1) (1 <=j<=k -1) which were obtained by taking a photograph in the direction which Image imn (n= 1, 2 --, j, --, k) is obtained, for example, adjoins each other like an image im1 and an image im2.

[0097] And in the image processing system concerning the gestalt 2 of this operation, as shown in drawing 18 (b), other images are stuck and the synthetic image IMC is obtained so that it may have consistency in the gap or one image imj chosen as a criteria image.

[0098] Drawing 19 is drawing showing the configuration of the image processing system 6 concerning the gestalt 2 of this operation. As shown in drawing 19 , although an image processing system 6 has the same configuration as the image processing system 1 concerning the gestalt 1 of the above-mentioned implementation shown in drawing 3 , it is different in that it has the image composition section 24 instead of the image-distortion amendment section 22. Here, although the image composition section 24 sticks an image with the field which overlaps mutually by carrying out coordinate transformation based on the relation of the focus and corresponding points which were obtained by the correspondence detecting element 21, it is later explained in detail about this actuation.

[0099] Drawing 20 is a flow chart which shows actuation of the image processing system 6 concerning the gestalt 2 of this operation shown in drawing 19 . First, an electric power switch 101 is changed, an image processing system 1 is started, and photography mode is chosen. Here, the above-mentioned photography mode consists of the normal mode which takes the usual snapshot, and gate amendment

mode which generates the image which amended the gate distortion of the photoed image. And selection in this photography mode is made when a user operates the photography mode setting key 104. In addition, as the photography mode setting section 19, the photography mode setting key 104 is formed in the body of an image processing system 1. However, the photography mode setting section 19 may consist of hardware or software etc. which are formed separately from a body.

[0100] And if it is judged whether it instigates in step S1 and amendment mode is chosen, and gate amendment mode is not chosen but the normal mode is chosen as shown in drawing 5 , it will progress to step S10 and the snapshot of a desired photographic subject will be taken by the user.

[0101] On the other hand, if it instigates in step S1 and amendment mode is chosen, it will progress to step S2. And a user photos at least two photographic subject sides PL by the image pick-up section 11, and a photographic subject image is incorporated by the image processing system 6. In addition, each image needs to be photoed so that some photographic subject images may overlap mutually at this time.

[0102] Next, it is judged whether the input of a photographic subject image was completed in step S3, when having not ended, it returns to step S2, and the input of a photographic subject image is continued further. On the other hand, when the input of a photographic subject image is ended with directions of the photography termination by the user, it progresses to step S4. In addition, the above-mentioned directions are made by pressing the photography mode setting key 104 once again, and changing to the normal mode, and also they may form the switch for directing photography termination separately.

[0103] And after photography of a photographic subject is completed as mentioned above, the actuation which generates the synthetic image which stuck the image of two or more sheets below on step S4 is started. In step S4, it chooses first on the basis of which image a synthetic image is generated. In addition, the image chosen at this time is the above-mentioned criteria image, and the case where the image imj shown in drawing 18 as an example is chosen as below as a criteria image is explained. Moreover, although a setup of this criteria image is made in the criteria image setting section 20, the configuration and actuation of the criteria image setting section 20 of it are the same as that of the case in the gestalt 1 of the above-mentioned implementation.

[0104] Next, in step S5, the image pair photoed from the adjoining direction shown in drawing 18 (a), i.e., the corresponding points which show the same part as the focus and this focus between images n (n+1) (1 <=n<=k -1), is detected. Detection of this focus and corresponding points is performed by the correspondence detecting element 21. Here, the configuration and actuation of the correspondence detecting element 21 are the same as that of the case in the gestalt 1 of the above-mentioned implementation.

[0105] And termination of detection of the focus and corresponding points sticks an image, after carrying out coordinate transformation based on the relation of both the acquired points so that it may have consistency in a criteria image. Here, when using projective transformation as coordinate transformation, while calculating a projective-transformation matrix in step S6, a synthetic image is generated by the above-mentioned lamination in step S7. Such calculation of a projective-transformation matrix and generation of a synthetic image are performed by the image composition section 24. The configuration and actuation of this image composition section 24 are explained in detail below.

[0106] Drawing 21 is drawing showing the configuration of the image composition section 24 shown in drawing 19 . As shown in drawing 21 , the image composition section 24 contains the projective-transformation calculation section 231 and the coordinate transformation section 232. Here, the projective-transformation calculation section 231 is connected to the criteria image setting section 20 and the correspondence detecting element 21, and the coordinate transformation section 232 is connected to the criteria image setting section 20, a frame memory 15, and the projective-transformation calculation section 231.

[0107] And the projective-transformation calculation section 231 computes the projective-transformation matrix B shown by the formula (3) using the group of the four or more focus and corresponding points. The calculation procedure is the same as that of the case in the gestalt 1 of the above-mentioned implementation, and should just perform least square count of a formula (5). It is necessary to calculate the projective-transformation matrix between the image pairs of an individual (k-

1) by setting in the gestalt of this operation, and to search for the projective-transformation matrix from each image to a criteria image further here.
[0108] As shown in drawing 18 , more specifically, they are Bn and a projective-transformation matrix from Image imn to Image imj about the projective-transformation matrix from Image imn (n= 1 to k-1) to Image im (n+1) [0109]
[Equation 25]
$B_{n \to j}$

If it sets, this projective-transformation matrix is calculable based on a degree type.
[0110]
[Equation 26]

$$B_{n \to j} = \begin{cases} \prod_{l=n}^{j-1} B_l & (n < j) \\ \left(\prod_{l=j}^{n-1} B_l \right)^{-1} & (n > j) \end{cases} \qquad (26)$$

Here, the coordinate transformation section 232 is stuck [Image / n] in the image [criteria] imj based on the projective-transformation matrix shown by the formula (26) computed by the projective-transformation calculation section 231. Specifically, the coordinate (x y) before the coordinate transformation in Image n corresponding to the coordinate after the coordinate transformation in a criteria image (X, Y) is first calculated based on a degree type.
[0111]
[Equation 27]

$$\begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = s B_{n \to j}^{-1} \begin{bmatrix} X \\ Y \\ 1 \end{bmatrix} \qquad (27)$$

However, s is a constant for setting the third component of the column vector of the left part in a formula (27) to 1. Next, a interpolation operation determines the pixel value of a coordinate (X, Y) based on a pixel value [/ near the coordinate before coordinate transformation (x y)]. And what is necessary is just to perform this interpolation operation using the existing approaches, such as a congruence linear interpolation method and B-spline interpolation method.
[0112] As mentioned above, according to the image processing system 6 concerning the gestalt of this operation, the photographic subject side PL is photoed two or more sheets, and the synthetic image crossed to the large field of the photographic subject side PL is generated by sticking other images to the selected criteria image so that parts may overlap mutually. In this case, by the criteria image setting section 20, since the image photoed from the direction which carries out a right pair mostly to a photographic subject, i.e., the small image of gate distortion, can be chosen as a criteria image, it can instigate as a result and the small overall photographic subject image of distortion can be obtained as the above-mentioned synthetic image.
After setting to the image processing system concerning the gestalten 1 and 2 of the [gestalt 3 of operation] above-mentioned implementation and inputting or photoing two or more photographic subject images previously, the criteria image which is made into the object of distortion amendment or is made into the criteria of a synthetic image is chosen. On the other hand, before the image processing system concerning the gestalt 3 of this operation photos a photographic subject, the above-mentioned criteria image is set up beforehand.
[0113] Drawing 22 is drawing showing the configuration of the image processing system 8 concerning the gestalt 3 of operation of this invention. As shown in drawing 22 , although the image processing

system 8 concerning the gestalt of this operation has the same configuration as the image processing system 1 concerning the gestalt 1 of operation shown in drawing 3 , it is different at the point further equipped with the notice section 26. Here, the notice section 26 is connected to the main control section 14 and the criteria image setting section 20.

[0114] In addition, the shutter 113 and interface 16 which were included in this image processing system 8 are connected to the main control section 14, and a finder 241 is connected to an interface 16.

[0115] Next, actuation of the image processing system 8 concerning the gestalt 3 of operation of this invention is explained, referring to the flow chart of drawing 23 . First, if it is judged whether it instigates in step S1 and amendment mode is chosen, and gate amendment mode is not chosen but the normal mode is chosen, it will progress to step S10 and the snapshot of a desired photographic subject will be taken by the user.

[0116] On the other hand, if it instigates in step S1 and amendment mode is chosen, it will progress to step S2. And in step S2, the image made applicable [of gate distortion] to amendment, i.e., a criteria image, is set as the criteria image setting section 20. The criteria image setting section 20 contains a cursor key 204 and the decision key 203 here, as shown in drawing 24 . And while an overlay indication of the alphabetic character "criteria image setup" is given at a display 17, it points so that the number of sheets photoed to a user after this and the criteria image assignment value which specifies whether the image photographed to the how many sheets in this photography is used as a criteria image may be set up. Here, a user can set up desired photography number of sheets and a criteria image assignment value by making the set point within the limit fluctuate by operating a cursor key 204 top or a down scrolling key by changing between setup of a criteria image to photography number of sheets, and operating the left or a rightward scrolling key. In addition, a setup of the above-mentioned criteria image is completed by pressing the decision key 203.

[0117] Next, in step S3, a user starts photography of the photographic subject image of at least two or more sheets. In addition, at this time, each image needs to be photoed so that parts may overlap mutually. And by supplying a photography signal to the main control section 14 from a shutter 113, whenever it photos an image, the increment of the counter built in the main control section 14 is carried out, and the number-of-sheets specification signal which shows the how many sheets the next photography is from this counter is supplied to the notice section 26. Since the signal which shows the above-mentioned criteria image assignment value from the criteria image setting section 20 is supplied to the register built in the notice section 26 here and the criteria image assignment value is stored in this register, In step S4, the notice section 26 compares the above-mentioned criteria image assignment value always stored in this register with the value which the above-mentioned number-of-sheets specification signal shows, and judges whether the image photoed shortly is what is used as a criteria image.

[0118] And in the above-mentioned comparison, both value is in agreement, when the image which it is going to photo from now on is what is used as a criteria image, it progresses to step S5, and the notice section 26 notifies a user of it being photography of a criteria image. That is, at this time, from the notice section 26, a notice signal is supplied to an interface 16 through the main control section 14, and as shown in drawing 25 , according to this notice signal, the indicator 242 of photographic subject image 35 width in a finder 241 is turned on with an interface 16. Therefore, it is recognized by the user at the time of photography whether it is photography of a criteria image easily. In addition, the notice in the above may be performed by displaying a predetermined text and a predetermined symbol on a display 17 etc.

[0119] Next, although it progresses to step S6, when the image photoed next in step S4 is judged not to consider as a criteria image, it progresses to the direct step S6. And in this step S6, when it is judged whether photography (input of a photographic subject image) of a photographic subject was completed and it is judged that it does not end, it returns to step S3. On the other hand, when it is judged that it ends, it progresses to step S7. Here, it shall be made by pushing the switch with which a setup [in / termination of photography is judged according to directions of a user, and / in these directions / the photography mode setting section 19] was changed to the normal mode, or was prepared for photography termination etc.

[0120] Next, at step S7, the focus is detected in a criteria image and the corresponding points which show the same part as the above-mentioned focus in the image which overlaps in these some criteria images [at least] are detected. Detection of such the focus and corresponding points is performed by the correspondence detecting element 21 shown in drawing 22 . In addition, the configuration and actuation of the this detecting element 21 are the same as that of the case of the gestalt 1 of the above-mentioned implementation.
[0121] And while computing the parameter for amending the gate distortion of a criteria image in step S8, the image which instigated based on the above-mentioned parameter in step S9, and amended distortion is generated, and actuation is ended. In addition, although generation of the image which amended calculation of this parameter and gate distortion is performed by the image-distortion amendment section 22, the configuration and actuation of this image-distortion amendment section 22 are the same as that of the case of the gestalt 1 of the above-mentioned implementation.
[0122] As mentioned above, since a user is notified by the notice section 26 in the image photography by the user by setting up a criteria image assignment value before photography of whether the image photoed next is what is used as a criteria image according to the image processing system 8 concerning the gestalt 3 of this operation, a user can recognize photography of a criteria image easily. And a user can pay [that the field of a request of a photographic subject especially goes into photographic coverage, and] attention at the time of photography of a criteria image. Furthermore, the photography mistake of a criteria image can be decreased.
[0123] In addition, it cannot be overemphasized that the technique which notifies a user of photography of a criteria image according to a setup of a criteria image assignment value by the notice section 26 can be applied also to the image processing system 6 concerning the gestalt 2 of the above-mentioned implementation.
Although the image processing system concerning the gestalt of the [gestalt 4 of operation] above-mentioned implementation needed to photo the photographic subject twice [at least] from a different direction by moving the single optical system included in the image pick-up section, with the image processing system concerning the gestalt of this operation, two or more optical system is installed in the image pick-up section 41 side by side, and two or more sheets are once obtained by photography in the photographic subject image photoed from a different direction.
[0124] Drawing 26 is drawing showing the configuration of the image processing system 40 concerning the gestalt 4 of operation of this invention. As shown in drawing 26 , although the image processing system 40 concerning the gestalt 4 of this operation has the same configuration as the image processing system 1 concerning the gestalt 1 of operation shown in drawing 3 , it is different from the image pick-up section 41 at a point including two optical system 11A and 11B.
[0125] Actuation of the image processing system applied to the gestalt of this operation below is explained referring to the flow chart of drawing 27 . First, an image processing system 40 is started and photography mode is chosen. Here, the above-mentioned photography mode consists of the normal mode which takes the usual snapshot, and gate amendment mode which generates the image which amended the gate distortion of the photoed image. And selection in this photography mode is made when a user operates a photography mode setting key. In addition, as the photography mode setting section 19, the photography mode setting key 104 is formed in the body of an image processing system 40. However, the photography mode setting section 19 may consist of hardware or software etc. which are formed separately from a body.
[0126] And if it is judged whether it instigates in step S1 and amendment mode is chosen, and gate amendment mode is not chosen but the normal mode is chosen as shown in drawing 27 , it will progress to step S10 and the snapshot of a desired photographic subject will be taken by the user.
[0127] The criteria image as an object which instigates in step S1, will progress to step S2 if amendment mode is chosen, instigates to the criteria image setting section 20 on the other hand, and amends distortion is set up. As shown in drawing 28 , the above scrolling key 201 and the down scrolling key 202, and the decision key 203 are contained in the criteria image setting section 20 here. Moreover, a user is asked for selection whether to use as the above-mentioned criteria image the image photoed by

which optical system 11A and 11B while an overlay indication of the alphabetic character "criteria image setup" is given at a display 17.
[0128] Then, by operating the above scrolling key 201 or the down scrolling key 202, a user moves the pointer shown with a triangle on a display 17, and specifies either the display the "camera 1" which chooses optical-system 11A, or the display the "camera 2" which chooses optical-system 11B. And if the above-mentioned pointer presses the decision key 203 where one of optical system is specified, let the image photoed by the this specified optical system be the above-mentioned criteria image. Here, the setting information on the above-mentioned criteria image is supplied to the main control section 14 from the criteria image setting section 20.
[0129] Next, in step S3, a user photos a photographic subject. At this time, it is easily checked [displaying only the image photoed by the optical system chosen at step S2 by control by the main control section 14, then] by the user at a display 17 whether the image which is going to amend gate distortion includes the range of the request of a photographic subject.
[0130] And in step S4, while the focus is detected within a criteria image, the corresponding points which show the same part as this focus within the image which has the field which overlapped the criteria image are detected. In addition, although detection of this focus and corresponding points is performed by the correspondence detecting element 21, the configuration and actuation of this correspondence detecting element 21 are the same as that of the case of the gestalt 1 of the above-mentioned implementation.
[0131] Next, while computing the parameter for amending the gate distortion of a criteria image in step S5, the image which instigated based on this parameter in step S6, and amended distortion is generated, and actuation is ended. Although generation of the image which amended calculation of the above-mentioned parameter and gate distortion is performed by the image-distortion amendment section 22 here, the configuration and actuation of this image-distortion amendment section 22 are the same as that of the case of the gestalt 1 of the above-mentioned implementation.
[0132] As mentioned above, according to the image processing system 40 concerning the gestalt 4 of this operation, since the image pick-up section 41 is equipped with at least two optical system, a user can get the amendment image obtained with the image processing system applied to the gestalt of the above-mentioned implementation by one photography actuation. Moreover, if only the image photoed in the selected optical system is displayed on a display 17, since whether the image which is going to amend gate distortion includes the range of the request of a photographic subject can check easily by the user, a user can pay attention further to photography of a criteria image, and can decrease the possibility of a photography mistake.
[0133] Moreover, it cannot be overemphasized that the image processing system 6 concerning the gestalt 2 of the above-mentioned implementation may be equipped with the image pick-up section which three or more optical system may be included in the image pick-up section 41 shown in drawing 26 , and includes such two or more optical system.
[0134] In addition, in the image processing system concerning the gestalt of implementation of all above, instead of photoing a photographic subject by the image pick-up section, the photographic subject image of two or more sheets stored in storages, such as storage, such as a hard disk, and CD-ROM, may be incorporated in enternal memory section 18 grade, and an amendment image may be generated using these photographic subject images. Moreover, that by which the photography mode setting section 19, the criteria image setting section 20, the correspondence detecting element 21, the image-distortion amendment section 22, and image composition section 24 grade are stored in case with the another image pick-up sections 11 and 41, for example, a computer etc., is considered to be the gestalt of the above-mentioned implementation the same way.
[0135] Moreover, although the correspondence detecting element 21 explained that corresponding points were detected by concentration matching by the correlation technique, you may carry out by another technique, such as a differentiation between space-time. Furthermore, in calculation of a gate distortion parameter, it is not restricted to the coordinate transformation shown in the above formulas (20), but other parameter calculation approaches may be applied.

In the gestalt of the [gestalt 5 of operation] above-mentioned implementation, although the coordinate transformation parameter was computed to the criteria image made into the object of an image processing and the distortion amendment image was generated using the interpolation operation, as for this criteria image, it is desirable that it is the image photoed by an image with little degradation of the image by the interpolation operation, i.e., the condition of having carried out the right pair to the photographic subject comparatively, including abundant paintings-and-calligraphic-works information. Then, the image processing system which performs the image-processing approach which chooses the optimal criteria image as below automatically, and this approach is explained.

[0136] Drawing 29 is drawing showing the first example of a configuration in the image processing system concerning the gestalt 5 of operation of this invention. As shown in drawing 29 , although the image processing system 50 concerning the gestalt 5 of this operation has the same configuration as the image processing system 1 concerning the gestalt 1 of operation shown in drawing 3 , it is different at the point equipped with the photographic subject field judging section 25 and the criteria image automatic selection section 27 instead of the criteria image setting section 20.

[0137] Here, the photographic subject field judging section 25 and the criteria image automatic selection section 27 are connected to the main control section 14, respectively, and the outgoing end of the photographic subject field judging section 25 is connected to the criteria image automatic selection section 27. Moreover, the outgoing end of the criteria image automatic selection section 27 is connected to the image-distortion amendment section 22.

[0138] In addition, also in the image processing system 50 concerning the gestalt 5 of this operation, as shown in drawing 4 , it can consider as the same configuration as the image processing system 1 concerning the gestalt 1 of the above-mentioned implementation.

[0139] It explains referring to the flow chart shown in drawing 30 in actuation of the image processing system 50 applied to the gestalt 5 of this operation below. The image processing system 50 applied to the gestalt 5 of this operation here is explained in detail focusing on difference below in order to operate like the image processing system 1 concerning the gestalt 1 of the above-mentioned implementation.

[0140] First, in step S1, when it is judged whether gate amendment mode is chosen, and gate amendment mode is not chosen but the normal mode is chosen, it progresses to step S10, and a desired snapshot is taken by the user by this user.

[0141] On the other hand, when it instigates by the user in step S1 and amendment mode is chosen, it progresses to step S2. And in step S2, the photographic subject image two-times photography was carried out [the image] at least by the image pick-up section 11 is incorporated to a frame memory 15. In addition, at this time, each image needs to be photoed so that these some photographic subject images may overlap mutually.

[0142] Next, it is judged whether the input of a photographic subject image was completed in step S3, when having not ended, it returns to step S2, and the input of a photographic subject image is continued further. On the other hand, when the input of a photographic subject image is ended with directions of the photography termination by the user, it progresses to step S4.

[0143] And in step S4, the focus is detected by the correspondence detecting element 21 in a photographic subject image, and the corresponding points which show the same part as the above-mentioned focus in the reference image which overlaps in these some photographic subject images [at least] are detected. Next, after detection of the focus and corresponding points is completed, the actuation which instigates below and amends distortion is started. And in step S5, the criteria image automatic selection section 27 makes first automatic selection of the criteria image which is instigated and is made into the object of distortion amendment. The criteria image automatic selection section 27 is explained in detail below.

[0144] In addition, the parameter for instigating in step S6 to the criteria image chosen in step S5 like the image processing system 1 concerning the gestalt 1 of the above-mentioned implementation, and amending distortion is calculated, the image which amended the gate distortion of an image based on this parameter in step S7 is created, and actuation is ended.

[0145] When amending gate distortion, it is suitable, if it crossed to the field where a photographic

subject side is the largest in two or more photoed images, and is reflected as the above-mentioned criteria image and an image with the abundant paintings-and-calligraphic-works amount of information which a user needs is chosen. Moreover, it is suitable if the image with the smallest possible angle (it is also called a "gate angle" to below) made to the photographic subject side of the image pick-up side at the time of photography is chosen. The reason is explained referring to drawing 31 .

[0146] Although the image-distortion amendment section 22 shown in drawing 29 is instigated by performing coordinate transformation by the formula (25) as mentioned above and distortion amendment is performed, this amendment actuation changes according to the gate angle phi. Here, in order to give explanation an easy thing, the gate angle phi is restricted to the circumference of the y-axis, and it is assumed that the magnitude of the plane of projection 31-ed parallel to a photographic subject side is equal to the magnitude of the image pick-up side 32.

[0147] As shown in drawing 31 (a), in the this [angle / phi / gate] coordinate transformation in the case of being comparatively small, the point near the left end of the image pick-up side 32 is projected by the variations shown by the vector which goes to Zero o to the plane of projection 31-ed. In addition, in the slash section in the plane of projection 31-ed, the resolution of a photographic subject image falls by such coordinate transformation.

[0148] On the other hand, as shown in drawing 31 (b), it instigates in this coordinate transformation, and the point near the left end of the image pick-up side 32 is projected on the plane of projection 31-ed with a bigger variations than the variations angle phi is indicated to be to drawing 31 (a) when comparatively large so that the position vector to Zero o may be reduced more greatly. And it turns out that the field to which the resolution of a photographic subject image falls by this coordinate transformation becomes large as compared with the case of drawing 31 (a).

[0149] It turns out that degradation of the resolution which followed, as mentioned above originated in the coordinate transformation by the image-distortion amendment section 22, so that the gate angle phi was small decreases.

[0150] Moreover, although the photographic subject field judging section 25 shown in drawing 29 detects the field which a photographic subject occupies in the photoed image For example, as indicated by reference "processing of an image and recognition" (Takeshi Akoin and Tomoharu Nagao collaboration, Shokodo) (a) How to cluster on an image like a field grown method or a field split plot experiment, (b) The field division approaches using the edge in images, such as the approach of clustering on feature spaces, such as field division by the histogram, and (c) profile line tracking, such as an approach and the (d) texture analysis, are applied. And the photographic subject field judging section 25 chooses the image which photoed the large range of a photographic subject according to this judgment result as the above-mentioned criteria image. Consequently, an image including paintings-and-calligraphic-works information abundant as a criteria image can be chosen automatically.

[0151] The image processing system applied to the gestalt 5 of operation of this invention here can also be considered as a configuration as shown in drawing 32 . That is, although the image processing system 51 shown in drawing 32 has the same configuration as the image processing system 50 shown in drawing 29 , it is different at the point equipped with the straight-line-like pattern detecting element 28 instead of the photographic subject field judging section 25.

[0152] Generally, in the photographic subject side which makes a document the start, many straight-lines [, such as a character string and a ruled line, / which have an parallel relation mutually]-like patterns exist. However, when the gate angle at the time of photography is large, it is projected on an image as a straight-line-like pattern in which the straight-line-like pattern which must originally be parallel has different sense. Therefore, by investigating dispersion in the sense of the straight-line-like pattern projected on the image, the size of this gate angle can be distinguished and an image with a small gate angle can be automatically chosen as a criteria image.

[0153] Here, the straight-line-like pattern detecting element 28 shown in drawing 32 performs processing which detects a straight-line-like pattern in two or more photoed images. And an example of the detection approach of this straight-line-like pattern is explained below.

[0154] First, an edge image is created by taking differential in these two or more images. Next, the

fragmentary edge point group in the created edge image is divided into a straight-line-like segment, and each straight-line-like segment is applied to the straight-line equation shown in the following equations (28).

ax+by+c=0 (a2+b2=1) (28)

here -- the above-mentioned formula (28) -- applying -- it is made by applying a least square method using the point group which constitutes a straight-line-like segment. And termination of the reliance panel of the straight line to a straight-line-like segment searches for dispersion in being a parameter showing the linear sense (a, b). Thus, dispersion in the sense of the straight line in each image can be known by searching for dispersion in the parameter to two or more above-mentioned images of all (a, b). And an image with the smallest dispersion in the linear sense can be automatically chosen as a criteria image.

[0155] Moreover, in automatic selection of a criteria image, the following approaches are also applicable. First, in two or more above-mentioned images, an edge image is created by the same approach as the above. Next, Hough conversion is performed to all the points in this edge image. Hough conversion is mathematical conversion used in order to detect a straight line from a fragmentary edge, and is the space constituted with the parameter of the formula expressing a line to detect here, and the approach of clustering is said. And more specifically, the sequence of points on an image are projected to the theta-rho space shown by the x axis, and angle theta and linear die-length rho to make.

[0156] Drawing 33 is drawing explaining Hough conversion to the theta-rho space shown in drawing 33 (b) from the image space shown in drawing 33 (a). Each point P1-P3 on an image is changed into drawing 33 by Hough conversion at the curves L1-L3 which correspond, respectively so that it may be shown. And although the point CP which the locus of this curve is concentrating in theta-rho space will arise if such conversion is performed about the all points on an image, this point CP is equivalent to the straight line which passes along many edge points in an edge image. If the coordinate of this point CP is set to (theta, rho), it will mean that the straight line corresponding to the following formula (29) was detected here.

Rho=xcostheta+ysintheta (29)

And dispersion in the sense of the straight line in each image can be known by extracting many points CP which this curve concentrates to two or more above-mentioned images of all, and searching for dispersion in theta in these points. Thus, what is necessary is just to choose automatically an image with the smallest dispersion in the linear sense as a criteria image.

[0157] Drawing 34 is drawing showing the third example of a configuration in the image processing system concerning the gestalt 5 of operation of this invention. As shown in drawing 34 , the image processing system concerning the gestalt 5 of this operation is good also as connecting the criteria image automatic selection section 27 to the correspondence detecting element 21, without having the photographic subject field judging section 25 shown in drawing 29 , and the straight-line-like pattern detecting element 28 shown in drawing 32 .

[0158] The group of the focus detected by the detecting element 21 corresponding to the above and corresponding points is used for count of the parameter which amends the projective-transformation matrix B, i.e., gate distortion. At this time, generally, and it is computed with so sufficient that they are distributing broadly a precision. [this parameter] [the group of the above-mentioned focus and corresponding points] Then, the distribution in the groups of the focus detected by the correspondence detecting element 21 and corresponding points and those images may be investigated to two or more photoed images, and the image those values of whose are maxes may be automatically chosen as a criteria image.

[0159] Moreover, in the correspondence detection based on the above-mentioned correlation technique, much focus and corresponding points are detected, so that there are many patterns which generally have the description in an image. And since possibility that many paintings-and-calligraphic-works information useful for a user in an image is included is high, if the focus and corresponding points make automatic selection of the abundant images as a criteria image, that there are many characteristic patterns can instigate an image including required paintings-and-calligraphic-works information, it can

set it as the object of distortion amendment, and is suitable.
[0160] Drawing 35 is drawing showing the fourth example of a configuration in the image processing system concerning the gestalt 5 of operation of this invention. As shown in drawing 35 , the image processing system concerning the gestalt 5 of this operation is good also as having the flat-surface measurement section 29 instead of the photographic subject field judging section 25 shown in drawing 29 , and the straight-line-like pattern detecting element 28 shown in drawing 32 .
[0161] Here, the flat-surface measurement section 29 measures the sense of the photographic subject over the image pick-up section 11 at the time of photography of each image. Drawing 36 is drawing showing the example of a configuration of the flat-surface measurement section 29 shown in drawing 35 . As shown in drawing 36 , the flat-surface measurement section 29 is equipped with the spot light source 271, a photo detector 272, the three-dimension coordinate calculation section 273, and the flat-surface calculation section 274, and the spot light source 271 contains light source 271a which consists of light emitting diode, semiconductor laser, etc., scan mirror 271b, such as a polygon mirror, and mechanical-component 271c which controls a motion of scan mirror 271b.
[0162] Here, in the above-mentioned spot light source 271, scan mirror 271b is controlled by mechanical-component 271c so that the spot light generated by light source 271a hits the photographic subject side PL. Moreover, a photo detector 272 is constituted by optoelectric transducers by which the location to the spot light source 271 was installed in the location measured beforehand, such as PSD (Position sensitive detector) and CCD, and detects the sense of the reflected light from the photographic subject side PL. In addition, the optoelectric transducer 114 contained in the image pick-up section 11 may be used as a photo detector 272 in the above.
[0163] Moreover, the three-dimension coordinate calculation section 273 computes the three-dimension coordinate (X, Y, Z) of the photographic subject side PL on the basis of an image processing system 53 by using the principle of triangulation according to the sense of spot light which the spot light source 271 irradiated, and the physical relationship of the spot light source 271 and a photo detector 272 and the sense of the reflected light which the photo detector 272 detected. And the flat-surface calculation section 274 presumes a flat-surface equation using the three-dimension coordinate of three or more points which is not on the same straight line computed by the three-dimension coordinate calculation section 273. For example, it is the flat-surface equation for which it asks aX+bY+cZ+d=0 (a2+b2+c2=1, c> 0) (30)
It sets and four parameters (a, b, c, d) in the above-mentioned flat-surface equation are calculated with a least square method using the three-dimension coordinate of three or more points. Consequently, the above-mentioned gate angle phi is calculated by the degree type (31).
Phi=cos - 1c (31)
Therefore, what is necessary is to measure the sense of a photographic subject side to two or more photoed images of all, and just to choose automatically the image the gate angle phi of whose is min as a criteria image.
[0164] In addition, as described in explanation of the image-distortion amendment section 22, it can ask for the sense of this photographic subject also by using the group of the focus and corresponding points which were detected by the correspondence detecting element 21. Therefore, the image processing system concerning the gestalt 5 of this operation can once perform a formula (14) thru/or a formula (18) in the image-distortion amendment section 22, can ask for the sense of a photographic subject, and can also consider the obtained result as the configuration of outputting to the criteria image automatic selection section 27.
As shown below in [the gestalt 6 of operation] at drawing 18 , the gestalt of the operation on condition of the case where the static image in the same photographic subject side PL is photoed from two or more directions so that it may overlap in some images, respectively is explained. In addition, as shown in drawing 18 here, by Hazama of Image imj and Image im (j+1) (1 <=j<=K -1) which were obtained by taking a photograph in the direction which Image imj (1 <=j<=K) is obtained, for example, adjoins each other like an image im1 and an image im2, there shall be a duplication field by taking a photograph from Direction dj, respectively. And in the image processing system concerning the gestalt 6 of this operation,

other images are stuck and a synthetic image is generated so that it may have consistency in the gap or one image chosen as a criteria image.
[0165] Drawing 37 is drawing showing the configuration of the image processing system 60 concerning the gestalt 6 of operation of this invention. As shown in drawing 37 , although the image processing system 60 concerning the gestalt 6 of this operation has the same configuration as the image processing system 6 concerning the gestalt 2 of operation shown in drawing 19 , it is different at the point equipped with the criteria image automatic selection section 27 instead of the criteria image setting section 20.
[0166] The image processing system 60 concerning the gestalt 6 of this operation which has the above configurations is explained focusing on difference, referring to the flow chart shown in drawing 38 in actuation of the image processing system 60 applied to the gestalt 6 of this operation below, although it operates like the image processing system 6 concerning the gestalt 2 of operation.
[0167] First, in step S1, when it is judged whether image composition mode is chosen, and image composition mode is not chosen but the normal mode is chosen, it progresses to step S10, and a desired snapshot is taken by the user by this user.
[0168] On the other hand, when image composition mode is chosen by the user in step S1, it progresses to step S2. And in step S2, two or more photographic subject images photoed by the image pick-up section 11 are incorporated to a frame memory 15. In addition, at this time, each image needs to be photoed so that these some photographic subject images may overlap mutually.
[0169] Next, it is judged whether the input of a photographic subject image was completed in step S3, when having not ended, it returns to step S2, and the input of a photographic subject image is continued further. On the other hand, when the input of a photographic subject image is ended with directions of the photography termination by the user, it progresses to step S4.
[0170] And in step S4, the focus is detected by the correspondence detecting element 21 between Image imj and Image im (j+1), and the corresponding points which show the same part as the above-mentioned focus in the image im (j+1) which overlaps in these some images [at least] imj are detected.
[0171] Next, after detection of this focus and these corresponding points is completed, the actuation which generates the synthetic image which stuck the image of two or more sheets on below is started. And in step S5, the criteria image automatic selection section 27 chooses automatically first the criteria image made into criteria in this composition. Here, the criteria image automatic selection section 27 chooses automatically the image with the above-mentioned smallest possible gate angle as a criteria image. And the synthetic small image of gate distortion can be obtained by performing such selection.
[0172] And in step S6, the projective-transformation matrix for performing composition on the basis of the criteria image chosen in step S5 is computed, a synthetic image is generated using this projective-transformation matrix in step S7, and actuation is ended.
[Gestalt 7 of operation] drawing 39 is drawing showing the configuration of the image processing system concerning the gestalt 7 of operation of this invention. As shown in drawing 39 , although the image processing system 70 concerning the gestalt 7 of this operation has the same configuration as the image processing system 1 concerning the gestalt 1 of operation shown in drawing 3 , it is different at the point further equipped with the criteria image automatic selection section 27 and the change section 45.
[0173] Here, the criteria image automatic selection section 27 is controlled by the main control section 14. Moreover, as for the change section 45, an outgoing end is connected to the image-distortion amendment section 22 while the input edge is connected to the criteria image setting section 20 and the criteria image automatic selection section 27.
[0174] Moreover, the change section 45 changes the selection approach of a criteria image, and as shown in drawing 40 , it contains the above scrolling key 201, the down scrolling key 202, and the decision key 203. Here, when a user pushes alternatively the menu screen key (not shown) displayed on a display 17, the screen where an overlay indication of the alphabetic character "selection of a criteria image" as shown in drawing 40 was given is displayed on a display 17.
[0175] And when the above scrolling key 201 or the down scrolling key 202 is operated by this user, the cursor of the triangle shown in drawing 40 carries out vertical migration. At this time, if the decision key

203 is pressed in the condition that this cursor has pointed out the alphabetic character of "AUTO", the criteria image automatic selection section 27 as which choosing a criteria image automatically was determined and it was indicated to be to drawing 39 will be activated alternatively. On the other hand, if the decision key 203 is pressed in the condition that this cursor has pointed out the alphabetic character of "MANUAL", the criteria image setting section 20 as which setting up a criteria image with hand control was determined, and it was indicated to be to drawing 39 will be activated alternatively.
[0176] Therefore, according to the image processing system concerning the gestalt 7 of this operation, by the change by the change section 45, since either the criteria image setting section 20 or the criteria image automatic selection section 27 is alternatively connectable with the image-distortion amendment section 22, a user can choose automatic or manual either as arbitration as the selection approach of a criteria image.
[0177] In addition, also in the gestalt of which operation mentioned above, the image-processing approach concerning the gestalt of this operation can be described as a computer program. And as shown in drawing 41 , the above-mentioned image processing is easily realizable by equipping an image processing system 1 with the record medium 301 which stored this program, and making an image processing system 1 perform this program.
[0178] Moreover, as shown in drawing 42 , the above-mentioned image processing is realizable also by equipping a personal computer (personal computer) PC with CD-ROM302 which stored this program, and performing this program with a personal computer PC. In addition, as a record medium with which a personal computer PC is equipped and which stores this program, it is not restricted to above-mentioned CD-ROM302, for example, it cannot be overemphasized that you may be DVD-ROM etc.
[0179] An example in case this program execution realizes the above-mentioned image-processing approach below is explained. In this case, an image processing system 1 and a personal computer PC are incorporated to the above-mentioned signal-processing section 12 through the various interfaces in which the photographic subject image of two or more sheets stored in record media, such as storage, such as built-in memory and a hard disk, and CD-ROM, was carried by the computer.
[0180] Moreover, a setup in the photography mode in the above is carried out by carrying out the mouse click of the icon displayed on push or a screen in the predetermined key in the keyboard of a personal computer PC. The image by which infanticide was carried out [above-mentioned] on the other hand by operating on a curtailed schedule and displaying two or more inputted images on a screen, pushing the vertical cursor key of the keyboard used for a calculating machine, or clicking on an icon with a mouse in choosing a criteria image with hand control etc. is chosen. And if a line feed key is pressed where a desired image is chosen, this image will be set up as a criteria image.
[0181] Moreover, about the focal distance f of the optical system which constitutes the image pick-up section 11, the focal distance of this optical system is measured beforehand, and it records on the interior of this record medium. And a user chooses the focal distance of the optical system used on the screen on the occasion of actual photography. Here, this focal distance is also recordable as header information. That is, when using an Exif format, for example as image data, the focal distance at the time of photography can be recorded as the header information. And the image processing system concerning the gestalt of this operation can obtain this focal distance by reading this header information. In addition, when the above approaches cannot be taken, it is good to display a dialog box etc. on screens, such as a personal computer PC, and to make a user do the manual entry of the direct focal distance into this dialog box.
[0182] Moreover, it can treat about direction of the photographic subject in the above as well as the above-mentioned focal distance. That is, the sense of the photographic subject measured by the flat-surface measurement section 29 or the image-distortion amendment section 22 is beforehand recorded as header information in an image data file, and the image processing system concerning the gestalt of this operation is good also as obtaining the sense of this photographic subject by reading this header information.
[0183] Although the field for recording the sense of a photographic subject does not exist in using an Exif format as this time, for example, image data, the sense of a photographic subject is recordable on

the field which the manufacturer called Maker Note can use freely.
[0184] Moreover, when the above approaches cannot be taken, it is good to display a dialog box etc. on screens, such as a personal computer PC, and to make it make a user input the sense of a direct photographic subject like the case of a focal distance.
[0185] In addition, the gestalt of operation of above-mentioned this invention can be applied to image processings using a digital still camera or a digital camcorder, such as a space information input and lamination composition of a division image, and can be applied also to the image device of a non-contact handy scanner or others.
[Effect of the Invention] Since the image optimal in order to obtain a proper image by choosing the object which amends distortion out of two or more images in the image-processing approach which amends distortion of the image photoed from two or more directions can be made applicable to amendment like **** according to this invention so that at least a part may overlap to a photographic subject, this more accurate amendment is realizable.
[0186] Moreover, distortion chooses fewest images from two or more images, and if the image which amended distortion is compounded with the this chosen image, a more proper synthetic image can be obtained.
[0187] Here, if the object of amendment is automatically chosen according to the size of the field which a photographic subject occupies into an image, since the paintings-and-calligraphic-works amount of information needed can amend distortion of the most abundant images automatically, a certainly proper image can be obtained.
[0188] Moreover, if the object of amendment is automatically chosen according to the sense of the straight-line-like pattern detected in an image, since the image photoed from the location which carried out the right pair to the photographic subject mostly can be automatically made applicable to amendment, a proper image with high resolution can be obtained.
[0189] Moreover, if the object of amendment is automatically chosen according to the specified correspondence relation, since high amendment of precision can be performed certainly, the dependability of an image processing can be raised.
[0190] Moreover, if the object of amendment is automatically chosen according to the sense of the photographic subject detected for every photography, since the image photoed from the location which carried out the right pair mostly to the photographic subject can be automatically made applicable to amendment, a proper image with high resolution can be obtained.
[0191] Moreover, since according to the image processing system equipped with a notice means to notify a user of becoming the image made into the criteria at the time of the image photoed next amending distortion attention is called in the photography of an image made into criteria to a user in case distortion is amended, the photography mistake by a user's inattention etc. is avoided and dependability of operation and the quality of an amendment image can be raised.
[0192] Moreover, according to the image processing system equipped with two or more optical means which photo a photographic subject to coincidence, and a selection means to choose the image made into the object of amendment among the images photoed by two or more optical means Since two or more photographic subject images once photoed by photography from two or more directions can be obtained, while actuation is made simple by decreasing the count of photography needed in order to amend distortion, the image with which distortion amendment was carried out more simply can be obtained.

[Translation done.]

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the record medium in which computer reading for realizing the image-processing approach, the image processing system, and this image-processing approach for not being based on a photography condition but obtaining a proper image in more detail about the image-processing approach, an image processing system, and a record medium is possible.
[0002]
[Description of the Prior Art] It will be necessary to also diversify the state of business with the rapid advance of a computer network, and to acquire important information quickly on all aspects of affairs. In connection with it, the demand to inputting goods required for business and document information simple and with high definition everywhere, making full use of the input device of a pocket mold is increasing. Especially, the application that it will utilize as electronic intelligence effective in work or amusement also came to be seen by performing processing and processing to the photoed image with rapid spread and its raise in resolving of a digital still camera.
[0003] Although the distortion of an image (this is also called "gate distortion".) arises as the first typical application when photoing photographic subject sides, such as A4 space and a large-sized poster, and an image pick-up side and a photographic subject side take a photograph in the condition which is not parallel, there is a technique of raising the readability of the document image information acquired by amending this. Here, in the image which wants to amend "gate distortion", it is required that the range of the request of a photographic subject should be copied. That is, it is necessary to photo at least one in the image of two or more sheets which the user photoed so that the range of the request of a photographic subject may be included. Therefore, the interface (I/F) which can choose the object which amends gate distortion among the photoed images of two or more sheets, and an interface to which suitable cautions are urged to a user at the time of photography are desired.
[0004] Moreover, there are some which create the synthetic image of one sheet by carrying out division photography of the pattern drawn on the space information and the panels of a large area, such as a newspaper, or a wall by the portable picture input device as the second application, and sticking the obtained image of two or more sheets. That is, although the resolution of a digital camera is improving in recent years with the increment in the number of pixels of the image sensor represented by CCD (Charge Coupled Device), photoing the photographic subject which has a pattern fine as mentioned above, i.e., the photographic subject containing a high frequency component, and electronizing runs short of resolution still more. Therefore, by sticking an image, a highly minute image is created in false and the approach of compensating the lack of resolution of a digital camera is made.
[0005] When a photographic subject can regard it as a plane, a geometric correction type like affine transformation or projective transformation is used, it is the technique which sticks the image which carried out division photography of some photographic subjects, and such an application changes the photographic subject image of each division image into how the photographic subject in the image used as criteria appears, and sticks. In addition, the outline of such a technique is indicated by reference

"computer vision-technical criticism and future view -" (new technical communique SHONZU besides Takashi Matsuyama).
[0006] However, in such an application, when it instigates in a photographic subject image in the image used as criteria and distortion has arisen, it instigates also in the stuck synthetic image and there is a problem that distortion will be included. That is, the magnitude of the gate distortion in the synthetic image generated changes by on the basis of which image lamination is performed among two or more images which took a photograph in division and were obtained. It explains referring to drawing 1 about this problem.
[0007] If these three images are stuck on the basis of the image IM 1 photoed and obtained from left slant to the photographic subject side PL when a certain photographic subject side PL is photoed from three ways D1-D3 and images IM1-IM3 are obtained, respectively as shown in drawing 1 (a) for example, the synthetic image IMA as shown in drawing 1 (b) will be obtained. Moreover, if it sticks similarly on the basis of the photoed image IM 2 from a transverse plane mostly, the synthetic image IMB as shown in drawing 1 (c) will be obtained. Here, as shown in drawing 1 (b) and drawing 1 (c), both the above-mentioned composition images IMA and IMB differ in the magnitude of gate distortion greatly.
[0008] Therefore, since a photograph is wanted to carry out the right pair of at least one in the photoed image of two or more sheets to the photographic subject side PL mostly, and to be taken, in case it is lamination among the photoed images of two or more sheets, when photoing the interface which chooses the image made into criteria, and the image used as the criteria of the lamination, an interface which demands cautions from a user is desired.
[0009]
[Problem(s) to be Solved by the Invention] This invention is made in view of an above-mentioned point, and aims at offering the record medium in which computer reading for realizing the image-processing approach, the image processing system, and this image-processing approach for amending distortion and obtaining a more proper image easily is possible.
[0010]
[Means for Solving the Problem] The above-mentioned purpose is the image-processing approach which amends distortion of the image photoed from two or more directions so that at least a part might overlap to a photographic subject. The first step which specifies the correspondence relation of the duplication part in two or more images obtained by photography, The second step which chooses the object which amends distortion from two or more images, It is attained by offering the image-processing approach characterized by having the third step which amends distortion of the image chosen at the second step according to the correspondence relation specified in the first step. Since the object which amends distortion is chosen according to such a means, in order to obtain a proper image, the optimal image can be made applicable to amendment.
[0011] You may make it choose the object of amendment automatically at the second step here according to the size of the field which a photographic subject occupies into an image. According to such a means, the paintings-and-calligraphic-works amount of information needed can amend distortion of the most abundant images automatically.
[0012] Moreover, you may make it choose the object of amendment automatically at the second step according to the sense of the straight-line-like pattern detected in an image. According to such a means, the image photoed from the location which carried out the right pair to the photographic subject mostly can be automatically made applicable to amendment.
[0013] Moreover, at the second step, if the object of amendment is automatically chosen according to the correspondence relation specified in the first step, high amendment of precision can be performed certainly.
[0014] Moreover, at the second step, if the object of amendment is automatically chosen according to the sense of the photographic subject detected for every photography, the image photoed from the location which carried out the right pair mostly to the photographic subject can be automatically made applicable to amendment.

[0015] Moreover, the purpose of this invention is the image-processing approach which amends distortion of the image photoed from two or more directions so that at least a part might overlap to a photographic subject. The first step which specifies the correspondence relation of the duplication part in two or more images obtained by photography, respectively, The second step as which distortion chooses fewest images from two or more images, According to the correspondence relation specified in the first step, distortion of two or more images is amended, respectively, and it is attained by offering the image-processing approach characterized by having the image chosen in the second step, and the third step to compound. According to such a means, since a synthetic image is generated on the basis of an image with least distortion, a more proper synthetic image can be obtained.
[0016] Moreover, the purpose of this invention is an image processing system which amends distortion of the image photoed from two or more directions so that at least a part might overlap to a photographic subject. A correspondence detection means to detect the correspondence relation of the duplication part in two or more images obtained by photography, It responds to the correspondence relation by which distortion was detected in a selection means to choose fewest images, and the correspondence detection means, out of two or more images. Distortion of two or more images is amended, respectively, and it is attained by offering the image processing system characterized by having the image chosen in the selection means, and an image composition means to compound.
[0017] Moreover, the purpose of this invention is an image processing system which amends distortion of the image photoed from two or more directions so that at least a part might overlap to a photographic subject. A selection means to choose beforehand the image made into the criteria at the time of amending distortion among two or more images to be photoed from now on, A notice means to notify a user of the image photoed next turning into an image made into criteria according to the selection made by the selection means, A correspondence detection means to detect the correspondence relation of the duplication part between the image made into the criteria acquired by taking a photograph, and other images, It is attained by offering the image processing system characterized by having an amendment means to amend the distortion of an image made into criteria, according to the correspondence relation detected by the correspondence detection means. According to such a means, in the photography of an image made into the criteria at the time of amending distortion, attention can be called to a user.
[0018] Moreover, the purpose of this invention is an image processing system which amends distortion of the image photoed from two or more directions so that at least a part might overlap to a photographic subject. A correspondence detection means to detect the correspondence relation of the duplication part in two or more images obtained by photography, It is attained by offering the image processing system characterized by having a selection means to choose the object which amends distortion from two or more images, and an amendment means to amend distortion of the image chosen by the selection means according to the correspondence relation detected by the correspondence detection means.
[0019] Moreover, two or more optical means which the purpose of this invention is an image processing system which amends distortion of the image photoed from two or more directions as at least a part overlaps to a photographic subject, and photo a photographic subject to coincidence, A selection means to choose the image made into the object of amendment among the images photoed by two or more optical means, A correspondence detection means to detect the correspondence relation of the duplication part between the image chosen by the selection means, and other images, It is attained by offering the image processing system characterized by having an amendment means to amend distortion of the selected image, according to the correspondence relation detected by the correspondence detection means. Since two or more photographic subject images once photoed by photography from two or more directions can be obtained according to such a means, the count of photography needed in order to amend distortion can be reduced.
[0020] Here, a selection means shall choose the object of amendment automatically according to the sense of the straight-line-like pattern which shall choose the object of amendment automatically according to the size of the field which a photographic subject occupies into an image, or is detected in an image. Moreover, a selection means is good also as what chooses the object of amendment automatically according to the sense of the photographic subject which should choose the object of

amendment automatically according to the correspondence relation detected by the correspondence detection means, or was detected for every photography.
[0021] Moreover, the purpose of this invention is a record medium which recorded the program for a computer to amend distortion of the image photoed from two or more directions so that at least a part might overlap to a photographic subject and in which computer reading is possible. This program makes the correspondence relation of the duplication part in two or more images obtained by photography specify to a computer. It is attained by offering the record medium which is characterized by making distortion of the image which was made to choose the object which amends distortion and was chosen according to the specified correspondence relation from two or more images amend and in which computer reading is possible. According to such a means, in order to obtain a proper image, the optimal image can be easily made applicable to amendment.
[0022] Moreover, the purpose of this invention is a record medium which recorded the program for a computer to amend distortion of the image photoed from two or more directions so that at least a part might overlap to a photographic subject and in which computer reading is possible. This program makes the correspondence relation of the duplication part in two or more images obtained by photography specify to a computer, respectively. It is attained by offering the record medium which is characterized by making it compound with the image which was made to amend distortion of two or more images, respectively, and was chosen according to the correspondence relation as which distortion made fewest images choose as and it was specified from two or more images and in which computer reading is possible. According to such a means, a more proper synthetic image can be obtained easily.
[0023]
[Embodiment of the Invention] The gestalt of operation of this invention is explained in detail with reference to a drawing below. In addition, a same-among drawing sign shows the same or a considerable part.
[Gestalt 1 of operation] drawing 2 is drawing for explaining the image-processing approach and image processing system concerning the gestalt 1 of operation of this invention. As the gestalt of this operation is shown to drawing 2 by here, the images 3 and 4 of two sheets are photoed so that a part of photographic subject side [at least] PL may overlap with an image processing system 1, and it is explained by the example of amending the gate distortion by either 3, for example, an image, among the images 3 and 4 of these two sheets, and finally obtaining the distortion amendment image 5.
[0024] Drawing 3 is drawing showing the configuration of the image processing system 1 concerning the gestalt 1 of operation of this invention. As shown in drawing 3 , an image processing system 1 is equipped with the image pick-up section 11, the signal-processing section 12, the memory control section 13, the main control section 14, a frame memory 15, an interface 16, a display 17, the enternal memory section 18, the photography mode setting section 19, the criteria image setting section 20, the correspondence detecting element 21, and the image-distortion amendment section 22. And the image pick-up section 11 contains a lens 111, diaphragm 112, a shutter 113, an optoelectric transducer 114, and the pretreatment section 115.
[0025] Here, the signal-processing section 12 is connected to the pretreatment section 115, the memory control section 13, the main control section 14, and an interface 16. Moreover, the memory control section 13 is further connected to a frame memory 15 and the criteria image setting section 20. The main control section 14 is further connected to the memory control section 13, the photography mode setting section 19, and the criteria image setting section 20.
[0026] Moreover, a frame memory 15 is connected to the memory control section 13, the correspondence detecting element 21, and the image-distortion amendment section 22. Moreover, an interface 16 is further connected to a display 17 and the enternal memory section 18. And the criteria image setting section 20 is further connected to the image-distortion amendment section 22. Moreover, the correspondence detecting element 21 is further connected to the image-distortion amendment section 22.
[0027] On the other hand, in the image pick-up section 11, it extracts as a lens 111, and 112, a shutter 113, and an optoelectric transducer 114 are arranged on an optical axis at this order, and an optoelectric

transducer 114 is connected to the pretreatment section 115.
[0028] In the above, photography mode is changed by the photography mode setting section 19, and the image which instigates in the criteria image setting section 20, and amends distortion is set up. Moreover, the correspondence detecting element 21 extracts the focus and corresponding points between both images in two images with which at least the part overlapped mutually. And the image-distortion amendment section 22 amends the gate distortion in the photoed image according to the signal supplied from the correspondence detecting element 21. In addition, a setup of the criteria image in the above, actuation of the correspondence detecting element 21, and amendment of gate distortion are explained in detail later.
[0029] Moreover, CCD is used for the optoelectric transducer 114 of the image pick-up section 11. Moreover, the pretreatment section 115 is equipped with the analog signal processing section and the analog-digital converter (A/D converter) which consist of pre amplifier, an automatic gain control circuit (Auto Gain Control-AGC), etc., and after pretreatment of magnification, a clamp, etc. is performed to the analog video signal outputted from the optoelectric transducer 114, the above-mentioned analog video signal is changed into a digital video signal.
[0030] Moreover, the signal-processing section 12 is constituted by the digital signal processor (DSP processor) etc., and performs various image processings, such as color separation, white balance adjustment, and gamma amendment, to the digital video signal acquired in the image pick-up section 11. Moreover, the memory control section 13 stores in a frame memory 15 the picture signal processed by doing in this way, or reads the picture signal conversely stored in the frame memory 15. Moreover, the main control section 14 is constituted by the microcomputer etc. Moreover, a frame memory 15 stores the image of at least two sheets, and, generally semiconductor memory, such as VRAM, SRAM, and DRAM, is used.
[0031] Here, the picture signal read from the frame memory 15 is saved in the enternal memory section 18 through an interface 16, after signal processing, such as picture compression, is performed in the signal-processing section 12. Reading and this enternal memory section 18 write various signals, such as a picture signal supplied through an interface 16, and is constituted by IC memory card, the magneto-optic disk, etc. As the enternal memory section 18, if a modem card and an ISDN card are used, a picture signal can also be transmitted to the record medium of a direct remote place via a network here.
[0032] Moreover, a picture signal is transmitted to the signal-processing section 12 through an interface 16, and read-out of the picture signal conversely recorded on the enternal memory section 18 is performed by giving image expanding in the signal-processing section 12. On the other hand, the display of the picture signal read from the enternal memory section 18 and a frame memory 15 is performed by transmitting to a display 17 through an interface 16, after performing signal processing, such as digital to analog (D/A conversion) and magnification, to a picture signal in the signal-processing section 12. A display 17 consists of liquid crystal displays which displayed the image according to the picture signal supplied through the interface 16, for example, were installed in the case of an image processing system 1 here.
[0033] Drawing 4 is the perspective view showing the image processing system shown in drawing 3 . As shown in drawing 4 , the image processing system 1 concerning the gestalt of this operation contains an electric power switch 101, a shutter 102, a finder 103, the photography mode setting key 104 for setting photography mode as the photography mode setting section 19, the above scrolling key 201 for scrolling upward the image projected on the display 17, the down scrolling key 202 for scrolling downward the image projected on the display 17, and the decision key 203.
[0034] It explains referring to the flow chart shown in drawing 4 and drawing 5 in actuation of the image processing system which has the above configurations below. First, an electric power switch 101 is changed, an image processing system 1 is started, and photography mode is chosen. Here, the above-mentioned photography mode consists of the normal mode which takes the usual snapshot, and gate amendment mode which generates the image which amended the gate distortion of the photoed image. And selection in this photography mode is made when a user operates the photography mode setting key 104. In addition, as the photography mode setting section 19, the photography mode setting key 104 is

formed in the body of an image processing system 1. However, the photography mode setting section 19 may consist of hardware or software etc. which are formed separately from a body.
[0035] And if it is judged whether it instigates in step S1 and amendment mode is chosen, and gate amendment mode is not chosen but the normal mode is chosen as shown in drawing 5 , it will progress to step S10 and the snapshot of a desired photographic subject will be taken by the user.
[0036] On the other hand, if it instigates in step S1 and amendment mode is chosen, it will progress to step S2. And a user photos at least two photographic subject sides PL by the image pick-up section 11, and a photographic subject image is incorporated by the image processing system 1. In addition, each image needs to be photoed so that some photographic subject images may overlap mutually at this time.
[0037] Next, it is judged whether the input of a photographic subject image was completed in step S3, when having not ended, it returns to step S2, and the input of a photographic subject image is continued further. On the other hand, when the input of a photographic subject image is ended with directions of the photography termination by the user, it progresses to step S4. In addition, the above-mentioned directions are made by pressing the photography mode setting key 104 once again, and changing to the normal mode, and also they may form the switch for directing photography termination separately.
[0038] Moreover, as shown during photography at drawing 6 , the screen overlay of the present photography number of sheets, such as "the 1st sheet", and the photography termination approaches, such as "ending, if a photography mode setting key is pressed", may be carried out to a display 17.
[0039] And although the actuation which instigates below to step S4 and amends distortion is started after photography is completed as mentioned above, it chooses the gate distortion of which image is first amended in step S4, and this image is set up. In addition, the image chosen at this time is also called a "criteria image" to below. And a setup of this criteria image is performed in the criteria image setting section 20. The configuration and actuation of the criteria image setting section 20 are explained in detail below.
[0040] Drawing 7 is drawing showing the layout of the criteria image setting section 20 shown in drawing 3 . As shown in drawing 7 , the criteria image setting section 20 contains the above scrolling key 201, and the down scrolling key 202 and the decision key 203. And as shown in drawing 7 , when directions of photography termination are made by the user in step S3, in a display 17, an overlay indication of the alphabetic character "criteria image setup" is given, and it points so that a criteria image may be chosen as a user.
[0041] Then, the above scrolling key 201 and the down scrolling key 202 are operated by the user, and it is displayed, the image photoed in the above-mentioned step S2 changing one by one. In addition, the image photoed after [of the image by which it is indicated by current] one is displayed by pressing the above scrolling key 201 by displaying the image photoed before [of the image by which it is indicated by current] one, and pressing the down scrolling key 202. And if the decision key 203 is pressed in the condition that the image chosen as a criteria image is displayed on the display 17, the image currently displayed at the time will be determined as a criteria image.
[0042] And the image with the smallest possible angle that crossed to the field where the photographic subject side PL is the largest, and has been reflected to it in two or more photoed images as the above-mentioned criteria image, and is made to the photographic subject side of the image pick-up side at the time of photography is chosen by the user.
[0043] Here, choosing automatically the image optimal as the object which calculates a photographic subject field and the above-mentioned tilt angle inside equipment, instigates according to the result of this count, and amends distortion, i.e., a criteria image, is also considered. Drawing 8 is drawing showing the configuration of the image processing system 2 which realizes such actuation. As shown in drawing 8 , an image processing system 2 is equipped with the photographic subject field decision section 23 instead of the criteria image setting section 20 contained in the image processing system 1 shown in drawing 3 .
[0044] And as the above-mentioned photographic subject field decision section 23 performs processing which detects the field which a photographic subject occupies in the photoed image, for example, it is indicated by reference "processing of an image and recognition" (Takeshi Akoin and Tomoharu Nagao

collaboration, Shokodo) (a) How to cluster on an image like a field grown method or a field split plot experiment, (b) The field division approaches using the edge in images, such as the approach of clustering on feature spaces, such as field division by the histogram, and (c) profile line tracking, such as an approach and the (d) texture analysis, are applied. However, when a photographic subject side is a rectangle, the field of a photographic subject is determined as a meaning by carrying out the external input of the top-most-vertices coordinate of the four corners of the photographic subject on an image.
[0045] Thus, the data in which the field of the photographic subject acquired in the photographic subject field decision section 23 is shown are supplied to the image-distortion amendment section 22, and an image with this largest field is chosen in the image-distortion amendment section 22. Furthermore, in the image-distortion amendment section 22, since the include angle made to the photographic subject side PL of an image pick-up side is calculated, when there are two or more images with the above-mentioned largest field (i.e., when there are two or more images with which for example, the whole photographic subject side is reflected), finally an image with the above-mentioned smallest include angle is chosen as a criteria image, so that it may explain in full detail below.
[0046] In addition, the above functions which choose a criteria image automatically are applicable similarly in the gestalt of which [of the following] operation.
[0047] Next, it progresses to step S5, the focus is detected in the criteria image determined as mentioned above, and the corresponding points which show the same part as the above-mentioned focus in the image (it is also called a "reference image" to below.) which overlaps in these some criteria images [at least] are detected. Detection of such the focus and corresponding points is performed by the correspondence detecting element 21 shown in drawing 3 . Then, the configuration and actuation of this correspondence detecting element 21 are explained in detail below.
[0048] The correspondence detecting element 21 detects the photoed same part in the image with the field which overlapped mutually as mentioned above of two sheets. And the approach which used the correlation operation here is explained.
[0049] Drawing 9 is drawing showing the configuration of the correspondence detecting element 21 shown in drawing 3 . As shown in drawing 9 , the correspondence detecting element 21 is equipped with the focus setting section 211 connected to the frame memory 15, and the correlation operation part 212 connected to the focus setting section 211 and a frame memory 15. In addition, the criteria image and the reference image are stored in the frame memory 15 shown in drawing 3 .
[0050] After the focus setting section 211 determines the location of the focus in a criteria image, it extracts the shade pattern of x (2N+1) (2P+1) individual centering on the focus, and creates the data of the field called a correlation aperture here. In addition, the location of the above-mentioned focus is determined by extracting the part where the concentration pattern of an image is characteristic like an angle (corner).
[0051] Moreover, the correlation operation part 212 detects the part which is mostly in agreement with the shade pattern of the correlation aperture created based on the criteria image by performing a correlation operation in a reference image, and determines this as corresponding points. An example which detects corresponding points by block matching by the correlation operation here is explained referring to drawing 10 .
[0052] As shown in drawing 10 , in block matching of the correlation aperture 215,216 which consists of a shade pattern of x (2N+1) (2P+1) individual, the cross-correlation value Si of the i-th focus 213 which has a coordinate in the criteria image 7 (xi0, yi0), and the corresponding points 217 which have a coordinate in the reference image 9 (xi0+dxi, yi0+dyi) is calculated by the degree type.
[0053]
[Equation 1]

$$S_i = \frac{1}{K} \sum_{x=-N}^{N} \sum_{y=-P}^{P} \left[I_s(x_{i0}+x, y_{i0}+y) - \overline{I_s(x_{i0}, y_{i0})} \right] \times \left[I_r(x_{i0}+dx_i+x, y_{i0}+dy_i+y) - \overline{I_r(x_{i0}+dx_i, y_{i0}+dy_i)} \right] \quad (1)$$

In addition, in the above-mentioned formula (1), Is (x y) shows concentration [in / for the concentration in the coordinate point (x y) of the criteria image 7 / in an example and Ir (x y) / the coordinate point (x y) of the reference image 9]. Moreover, Is (x y) shows the average concentration in the pattern of x (2N+1) (2P+1) individual centering on the coordinate point in the /correlation aperture 215 in the criteria image 7 (x y). Ir (x y) shows the average concentration in the pattern of x (2N+1) (2P+1) individual centering on the coordinate point in the /correlation aperture 216 in the reference image 9 (x y). Moreover, K shows a constant.

[0054] And the corresponding points 217 in the reference image 9 are called for by searching for the point which is beyond the threshold as which the maximum of the cross-correlation value Si was beforehand determined by the above-mentioned formula (1) to each focus 213. In addition, if the maximum of the cross-correlation value Si becomes below a threshold, corresponding points shall not exist.

[0055] Thus, after detection of the focus and corresponding points is completed, while calculating the parameter which amends the gate distortion of the criteria image 7 in step S6 shown in drawing 5 , the image which amended the gate distortion of an image based on this parameter in step S7 is created, and actuation is ended. In addition, the image which amended a "distortion amendment parameter" and gate distortion for the above-mentioned parameter below, respectively is also called "distortion amendment image."

[0056] And count of the above-mentioned distortion amendment parameter and generation of a distortion amendment image are performed by the image-distortion amendment section 22. The configuration and actuation of this image-distortion amendment section 22 are explained in detail below.

[0057] The image-distortion amendment section 22 amends gate distortion by changing into the image which photoed the photographic subject side from the transverse plane using the relation of the focus and corresponding points which the correspondence detecting element 21 detected. And the configuration of this image-distortion amendment section 22 is shown in drawing 11 . As shown in drawing 11 , the image-distortion amendment section 22 contains the three-dimension operation part 221, the parameter calculation section 222, and the coordinate transformation section 223. Here, the three-dimension operation part 221 is connected to the correspondence detecting element 21 and the criteria image setting section 20, and the parameter calculation section 222 is connected to the three-dimension operation part 221. Moreover, the coordinate transformation section 223 is connected to the parameter calculation section 222, a frame memory 15, and the criteria image setting section 20.

[0058] Actuation of the image-distortion amendment section 22 is explained below. In addition, as shown below at drawing 12 , while the criteria image 7 and the reference image 9 are photoed to the photographic subject side PL As the optical system of the image pick-up section 11 is shown in drawing 13 , it is related with a x axis. Facing the right of the image side 224 Forward, The sense which goes facing down of the image side 224 to the image side 224 about the z-axis of forward and the direction of an optical axis about the y-axis from the zero O which is the optical axis of the image pick-up section 11 Forward, The focal distance of this optical system explains as an example the case where it considers as the central projection model (perspectiveprojection model) set to f.

[0059] The three-dimension operation part 221 shown in drawing 11 computes the following three-dimension parameters with the relation between the above-mentioned focus 213 and corresponding points 217. That is, normal vector n which shows the sense of the translational-motion vector t which shows change of the location of the image pick-up section 11 at the time of the reference image photography based on the time of the rotation matrix R which shows change of the sense of the image pick-up section 11 at the time of the reference image photography based on the time of the criteria image photography shown in drawing 12 , and criteria image photography, and the photographic subject side PL is computed. And the method of asking for these three three-dimension parameters {R, t, n} is mainly made into two of the followings.

[0060] that is, as a primary method, by the group of the eight or more focus and corresponding points, after calculating the location of the camera at the time of each image photography, a posture, and the

three-dimension coordinate of each corresponding points, it assumes that a photographic subject is a flat surface, and there is a method of applying this profit **** three-dimension coordinate to one flat surface.

[0061] Moreover, as the second approach, from the group of the four or more focus and corresponding points, a projective-transformation matrix (homography matrix) is calculated and there is the approach of computing the location of the camera at the time of each image photography and the sense of a posture and a photographic subject side according to the acquired projective-transformation matrix.

[0062] Here, although the above-mentioned primary method is a general-purpose movement stereoscopic vision technique and a meaning is asked for the above-mentioned parameter {R, t, n} by the linearity operation, the detail is recorded on the common reference (for example, "three-dimension vision" **** and crossing Saburo collaboration, KYORITSU SHUPPAN) about three-dimension measurement or a computer vision. On the other hand, the second approach of the above computes the sense of a camera, and the sense of a photographic subject side, after asking for the coordinate transformation equation (projective-transformation matrix) materialized under the constraint that a photographic subject is a flat surface. And although the three-dimension operation part 221 can, needless to say, take any [the above-mentioned first and / second] approach, it explains the actuation based on the second approach here.

[0063] The calculation procedure of a projective-transformation matrix is explained in detail first. Here, it points out obtaining the image 10 changed into the image obtained when the photographic subject image reflected to the criteria image 7 is photoed from the same direction as the reference image 9, as indicated in drawing 14 as the projective transformation from a criteria image to a reference image. And when this projective transformation is expressed with a formula and the point (xs, ys) in a criteria image and the point (xr, yr) in a reference image have a correspondence relation, it becomes like a degree type.

[0064]

[Equation 2]

$$\begin{cases} x_r = \dfrac{b_1 x_s + b_2 y_s + b_3}{b_7 x_s + b_8 y_s + 1} \\ y_r = \dfrac{b_4 x_s + b_5 y_s + b_6}{b_7 x_s + b_8 y_s + 1} \end{cases} \quad (2)$$

And they are eight unknowns b1-b8 in the above-mentioned formula (2) [0065]

[Equation 3]

$$B = \begin{bmatrix} b_1 & b_2 & b_3 \\ b_4 & b_5 & b_6 \\ b_7 & b_8 & 1 \end{bmatrix} \quad (3)$$

It collects as a matrix B and this is called a projective-transformation matrix. In order to search for this projective-transformation matrix B, 4 or more sets of groups of the focus whose coordinates in a criteria image are (xsi, ysi), and the corresponding points (i= 1, --, N;N>=4) whose coordinates in a reference image are (xri, yri) are used. Here, although what is necessary is to substitute a coordinate (xsi, ysi) and a coordinate (xri, yri) to the above-mentioned formula (2), and just to calculate the solution of b1-b8, since a formula (2) is not materialized according to errors, such as a noise superimposed on an image in fact, it will solve using the least square operation shown below.

[0066]

[Equation 4]

$$\sum_{i=1}^{N} \left[\left(\frac{b_1 x_{si} + b_2 y_{si} + b_3}{b_7 x_{si} + b_8 y_{si} + 1} - x_{ri} \right)^2 + \left(\frac{b_4 x_{si} + b_5 y_{si} + b_6}{b_7 x_{si} + b_8 y_{si} + 1} - y_{ri} \right)^2 \right] \rightarrow \min. \quad (4)$$

And the above-mentioned formula (4) deforms as follows.
[0067]
[Equation 5]

$$\sum_{i=1}^{N} [(b_1 x_{si} + b_2 y_{si} + b_3 - (b_7 x_{si} + b_8 y_{si} + 1)x_{ri})^2 + (b_4 x_{si} + b_5 y_{si} + b_6 - (b_7 x_{si} + b_8 y_{si} + 1)y_{ri})^2] \rightarrow \min. \quad (5)$$

Use of the constraint that the value of the derivative obtained by carrying out strange differential of the left part of the above-mentioned equation (5) by b1-b8, respectively is set to 0 calculates b1-b8 by solving a simultaneous equation. That is, the projective-transformation matrix B can be searched for by the easy linearity operation using the group matched the account of a top.
[0068] Then, the procedure of asking for a three-dimension parameter {R, t, n} from the projective-transformation matrix B is explained. It is normal vector n of a photographic subject side [0069]
[Equation 6]

$$n = \begin{bmatrix} a \\ b \\ c \end{bmatrix} \qquad (a^2 + b^2 + c^2 = 1,\ c > 0) \quad (6)$$

It is the equation of the photographic subject [carry out and] side on the basis of the time of criteria image photography [0070]
[Equation 7]

$$(n, r) + d = 0 \quad (7)$$

Here, |d| shows the distance from the zero to the photographic subject side PL, and is r=[x y z] T. It sets. Moreover, a formula (2) is rewritten like a degree type using a focal distance f.
[0071]
[Equation 8]

$$\begin{cases} x_r = f \dfrac{H_{11} x_s + H_{21} y_s + H_{31} f}{H_{13} x_s + H_{23} y_s + H_{33} f} \\ y_r = f \dfrac{H_{12} x_s + H_{22} y_s + H_{32} f}{H_{13} x_s + H_{23} y_s + H_{33} f} \end{cases} \quad (8)$$

Furthermore, a formula (8) is [0072].
[Equation 9]

$$\begin{bmatrix} x_r \\ y_r \\ f \end{bmatrix} = s \begin{bmatrix} H_{11} & H_{21} & H_{31} \\ H_{12} & H_{22} & H_{32} \\ H_{13} & H_{23} & H_{33} \end{bmatrix} \begin{bmatrix} x_s \\ y_s \\ f \end{bmatrix} = s H^T \begin{bmatrix} x_s \\ y_s \\ f \end{bmatrix} \quad (9)$$

It deforms. However, [0073]
[Equation 10]

$$s = \frac{1}{H_{13} x_s + H_{23} y_s + H_{33} f} \quad (10)$$

It comes out. At this time, the matrix H of a formula (9) and the relation with a parameter {R, t, n, d} become like a degree type.

[0074]

[Equation 11]

$$H^T = s' R^T \left(dI + t n^T \right) \tag{11}$$

However, s' is a constant and each element of Matrix H has one times the degree of freedom of a scale. Moreover, a degree type can perform conversion in procession H of a formula (9) from the projective-transformation matrix B of a formula (3).

[0075]

[Equation 12]

$$H^T = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & f \end{bmatrix} B \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1/f \end{bmatrix} = \begin{bmatrix} b_1 & b_2 & b_3/f \\ b_4 & b_5 & b_6/f \\ fb_7 & fb_8 & 1 \end{bmatrix} \tag{12}$$

The procedure of asking below for a parameter {R, t, n, d} stranger than Matrix H is shown. However, since it is unfixed, Variable d and the scale of the magnitude of the translational-motion vector t showing distance with a photographic subject side are [0076].

[Equation 13]

$$\|t\| = 1 \tag{13}$$

It assumes. Here, although the detail is describing in reference "mathematical principle of image comprehension-three-dimension recognition -" (Ken-ichi Kaneya work, Morikita Shuppan), the computation which derives the solution {R, t, n, d} to is as follows when the result is summarized.
(i) It is made to be set to det[H] =1, applying the suitable constant for each element of the matrix H of a formula (9). (ii) Characteristic value of a symmetric matrix HHT is set to sigma12, sigma22, and sigma32, the corresponding characteristic vectors u1, u2, and u3 are mutually intersected perpendicularly, and it takes to the unit vector which makes a right-hand system in this order. However, sigma1>=sigma2>=sigma3> It is referred to as 0. (iii) A movement parameter will be [0077] if it becomes sigma1=sigma2=sigma3.

[Equation 14]

$$t = 0, \quad R = H \tag{14}$$

It comes out, and it is and the parameter {n, d} of a photographic subject side is unfixed. Otherwise, 2 sets of solutions are acquired as follows. (iv) The parameter {n, d} of a photographic subject side becomes settled as follows.

[0078]

[Equation 15]

$$n = \frac{\varepsilon}{\sqrt{\sigma_1^2 - \sigma_3^2}} \left(\pm \sqrt{\sigma_1^2 - \sigma_2^2}\, u_1 + \sqrt{\sigma_2^2 - \sigma_3^2}\, u_3 \right) \tag{15}$$

[0079]

[Equation 16]

$$d = -\frac{\sigma_2}{\sigma_1 - \sigma_3} \tag{16}$$

However, it is epsilon= **1, and epsilon is chosen so that it may be set to c> 0. Moreover, (v) unit translational-motion vector t becomes settled as follows.

[0080]

[Equation 17]

$$t = \frac{1}{\sigma_2\sqrt{\sigma_1^2 - \sigma_3^2}}\left(\pm\sigma_3\sqrt{\sigma_1^2 - \sigma_2^2}u_1 - \sigma_1\sqrt{\sigma_2^2 - \sigma_3^2}u_3\right) \text{ (複号同順)} \quad (17)$$

Moreover, the rotation matrix R becomes settled as follows.

[0081]

[Equation 18]

$$R = \frac{1}{\sigma_2}\left[I - \frac{1}{(n,\ t) + d}nt^T\right]H \quad (18)$$

Therefore, although two kinds of solutions {R, t, n, d} to are acquired from Matrix B, when the most, a true solution can be distinguished from the drawn value. In addition, although the focal distance f of the image pick-up section 11 is used by intermediate count, the value of a focal distance f can be easily obtained by the approach of memorizing the optical-system parameter of the image pick-up section 11 to an internal memory (not shown). Moreover, if the focal distance of both images is known even when the focal distances of a criteria image and a reference image differ [the focal distance of the optical system of the image pick-up section 11] with adjustable, the above-mentioned three-dimension parameter calculation procedure can be applied as it is, and a focal distance can be detected by the approach of installing an encoder in optical system.

[0082] Next, the parameter calculation section 222 shown in drawing 11 calculates the parameter which amends gate distortion based on relation with the sense of the photographic subject side computed by the image pick-up section 11 and the three-dimension operation part 221 when photoing a photographic subject side. As the gestalt of this operation is shown to drawing 15 by here, the gate distortion of an image is amended by performing projective transformation of projecting the image side 30 containing the photographic subject image which has gate distortion, by using as the plane of projection 31-ed a flat surface parallel to the photographic subject side which the three-dimension operation part 221 computed. The point P1 on the image side 30 is projected on the point P2 on the plane of projection 31-ed here. The count approach of the parameter which amends the above-mentioned gate distortion below is explained.

[0083] First, as shown in drawing 16 , it asks for rotation matrix R' which shows the coordinate transformation which makes the z-axis in the device-coordinate system 33 in agreement with the unit normal vector of the plane of projection 31-ed. In this case, the following relational expression is materialized.

[0084]

[Equation 19]

$$R'\begin{bmatrix}0\\0\\1\end{bmatrix} = \begin{bmatrix}a\\b\\c\end{bmatrix} \quad (19)$$

And although much rotation matrix R' which fills the above-mentioned formula (9) exists, rotation matrix R' is defined like a degree type here.

[0085]

[Equation 20]

$$R' = R'_y R'_x = \begin{bmatrix}R'_{11} & R'_{12} & R'_{13}\\ R'_{21} & R'_{22} & R'_{23}\\ R'_{31} & R'_{32} & R'_{33}\end{bmatrix} \quad (20)$$

However, R'x and R'y are shown as follows here, respectively.

[0086]
[Equation 21]

$$R'_x = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\alpha & -\sin\alpha \\ 0 & \sin\alpha & \cos\alpha \end{bmatrix}, \quad R'_y = \begin{bmatrix} \cos\beta & 0 & \sin\beta \\ 0 & 1 & 0 \\ -\sin\beta & 0 & \cos\beta \end{bmatrix} \tag{21}$$

As shown in drawing 17 , this rotates the device-coordinate system (xyz system of coordinates) 33 in following sequence, and is equivalent to changing into x'y'z' system of coordinates. (i) beta rotation of the device-coordinate system 33 is done only around the y-axis. And let the system of coordinates obtained by this rotation be 1y1zx1 system of coordinates. (ii) Only alpha rotates a device-coordinate system around x1 shaft.
[0087] Here, if a formula (19) and a formula (20) are used, an angle of rotation will be drawn like a degree type.
[0088]
[Equation 22]

$$\alpha = \sin^{-1}(-b) \tag{22}$$

$$\beta = \sin^{-1}\left(\frac{a}{\sqrt{a^2 + c^2}}\right) \tag{23}$$

And matrix R' can be set to a meaning by substituting for a formula (20) and a formula (21) the angle of rotation searched for in this way.
[0089] Next, coordinate transformation of the coordinate on the image side 30 is carried out on the plane of projection 31-ed. That is, let the point P2 which intersects the plane of projection 31-ed when the three-dimension vector p corresponding to the point P1 of the image side 30 is extended be a coordinate after coordinate transformation in drawing 15 . And the three-dimension vector p corresponding to the point P1 on the basis of the device-coordinate system 33 is shown by the degree type.
[0090]
[Equation 23]

$$P = \frac{k}{ax_s + by_s + cf}\begin{bmatrix} x_s \\ y_s \\ f \end{bmatrix} \quad (k > 0) \tag{24}$$

Here, since k is a scaling factor showing the distance from the optical axis o of the image pick-up section 11 to plane of projection-ed, k expresses the magnitude of the distortion amendment image created. moreover -- a three dimension -- a vector -- p -- criteria -- an image -- photography -- the time -- a device coordinate -- a system -- 33 -- criteria -- carrying out -- a point -- P -- one -- having expressed -- a vector -- it is -- although -- this -- rotation -- a matrix -- R -- ' -- using -- a degree -- a type -- like -- coordinate transformation -- carrying out -- things -- an image pick-up -- the section -- 11 -- a photographic subject -- a field -- right -- a pair -- carrying out -- having made -- the time -- a three dimension -- a vector -- p -- ' -- changing -- having .
[0091]
[Equation 24]

$$P' = \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = R'^{-1}P = \frac{k}{ax_s + by_s + cf}\begin{bmatrix} R'_{11} & R'_{21} & R'_{31} \\ R'_{12} & R'_{22} & R'_{32} \\ R'_{13} & R'_{23} & R'_{33} \end{bmatrix}\begin{bmatrix} x_s \\ y_s \\ f \end{bmatrix} \tag{25}$$

Therefore, the image which amended gate distortion is obtained by making the x-coordinate and y-

coordinate of a formula (25) into the coordinate acquired after coordinate transformation. And the parameter which amends the gate distortion of a criteria image using a formula (25) is computable with the above procedures.

[0092] Next, the coordinate transformation section 223 coordinate-transformation-creates a distortion amendment image for a criteria image based on the gate distortion amendment parameter computed by the parameter calculation section 222. The coordinate (xs, ys) before the conversion corresponding to the coordinate after coordinate transformation (X, Y) is calculated based on a formula (25), and, specifically, a interpolation operation determines the pixel value in a coordinate (X, Y) based on a pixel value [/ near the calculated coordinate (xs, ys)]. In addition, what is necessary is just to perform this interpolation operation using the existing approaches, such as a congruence linear interpolation method and B-spline interpolation method.

[0093] As mentioned above, when according to the image processing system concerning the gestalt 1 of operation of this invention a photographic subject side is photoed two or more sheets so that at least parts may overlap mutually, the gate distortion in the image of the photoed arbitration can be amended, and the overview of a more proper photographic subject can be obtained.

[0094] That is, it is sufficient, if there are an image which photoed the whole photographic subject, and an image which photoed some photographic subjects as it is necessary to photo all the range of a photographic subject in no images in the above-mentioned procedure for example, and is shown in drawing 14 . And since the image which photoed the whole photographic subject by the criteria image setting section 20 can be chosen as a criteria image in such a case, the overview of the photographic subject with which gate distortion was amended is generable.

[0095] Moreover, if the number of sheets to photo is limited to two sheets since there should just be a photographic subject image of two sheets at worst in order to generate a distortion amendment image by the above-mentioned approach, count cost which the input of an image and a setup of photography and a criteria image are not only simplified for a user, but detection of memory space, the focus, and corresponding points required in order to memorize an image, and count of a projective-transformation matrix take can be made small.

[Gestalt 2 of operation] drawing 18 is drawing for explaining the image-processing approach and image processing system concerning the gestalt 2 of operation of this invention. As shown in drawing 18 (a), actuation of the image processing system 6 concerning the gestalt of this operation when the static image of the same photographic subject side PL is photoed from two or more directions d1-dk so that it may overlap in some images, respectively is explained.

[0096] Here, as shown in drawing 18 (a), suppose that there is a duplication field, respectively by taking a photograph from Direction Dn by Hazama of Image imj and Image im (j+1) (1 <=j<=k -1) which were obtained by taking a photograph in the direction which Image imn (n= 1, 2 --, j, --, k) is obtained, for example, adjoins each other like an image im1 and an image im2.

[0097] And in the image processing system concerning the gestalt 2 of this operation, as shown in drawing 18 (b), other images are stuck and the synthetic image IMC is obtained so that it may have consistency in the gap or one image imj chosen as a criteria image.

[0098] Drawing 19 is drawing showing the configuration of the image processing system 6 concerning the gestalt 2 of this operation. As shown in drawing 19 , although an image processing system 6 has the same configuration as the image processing system 1 concerning the gestalt 1 of the above-mentioned implementation shown in drawing 3 , it is different in that it has the image composition section 24 instead of the image-distortion amendment section 22. Here, although the image composition section 24 sticks an image with the field which overlaps mutually by carrying out coordinate transformation based on the relation of the focus and corresponding points which were obtained by the correspondence detecting element 21, it is later explained in detail about this actuation.

[0099] Drawing 20 is a flow chart which shows actuation of the image processing system 6 concerning the gestalt 2 of this operation shown in drawing 19 . First, an electric power switch 101 is changed, an image processing system 1 is started, and photography mode is chosen. Here, the above-mentioned photography mode consists of the normal mode which takes the usual snapshot, and gate amendment

mode which generates the image which amended the gate distortion of the photoed image. And selection in this photography mode is made when a user operates the photography mode setting key 104. In addition, as the photography mode setting section 19, the photography mode setting key 104 is formed in the body of an image processing system 1. However, the photography mode setting section 19 may consist of hardware or software etc. which are formed separately from a body.

[0100] And if it is judged whether it instigates in step S1 and amendment mode is chosen, and gate amendment mode is not chosen but the normal mode is chosen as shown in drawing 5 , it will progress to step S10 and the snapshot of a desired photographic subject will be taken by the user.

[0101] On the other hand, if it instigates in step S1 and amendment mode is chosen, it will progress to step S2. And a user photos at least two photographic subject sides PL by the image pick-up section 11, and a photographic subject image is incorporated by the image processing system 6. In addition, each image needs to be photoed so that some photographic subject images may overlap mutually at this time.

[0102] Next, it is judged whether the input of a photographic subject image was completed in step S3, when having not ended, it returns to step S2, and the input of a photographic subject image is continued further. On the other hand, when the input of a photographic subject image is ended with directions of the photography termination by the user, it progresses to step S4. In addition, the above-mentioned directions are made by pressing the photography mode setting key 104 once again, and changing to the normal mode, and also they may form the switch for directing photography termination separately.

[0103] And after photography of a photographic subject is completed as mentioned above, the actuation which generates the synthetic image which stuck the image of two or more sheets below on step S4 is started. In step S4, it chooses first on the basis of which image a synthetic image is generated. In addition, the image chosen at this time is the above-mentioned criteria image, and the case where the image imj shown in drawing 18 as an example is chosen as below as a criteria image is explained. Moreover, although a setup of this criteria image is made in the criteria image setting section 20, the configuration and actuation of the criteria image setting section 20 of it are the same as that of the case in the gestalt 1 of the above-mentioned implementation.

[0104] Next, in step S5, the image pair photoed from the adjoining direction shown in drawing 18 (a), i.e., the corresponding points which show the same part as the focus and this focus between images n (n+1) (1 <=n<=k -1), is detected. Detection of this focus and corresponding points is performed by the correspondence detecting element 21. Here, the configuration and actuation of the correspondence detecting element 21 are the same as that of the case in the gestalt 1 of the above-mentioned implementation.

[0105] And termination of detection of the focus and corresponding points sticks an image, after carrying out coordinate transformation based on the relation of both the acquired points so that it may have consistency in a criteria image. Here, when using projective transformation as coordinate transformation, while calculating a projective-transformation matrix in step S6, a synthetic image is generated by the above-mentioned lamination in step S7. Such calculation of a projective-transformation matrix and generation of a synthetic image are performed by the image composition section 24. The configuration and actuation of this image composition section 24 are explained in detail below.

[0106] Drawing 21 is drawing showing the configuration of the image composition section 24 shown in drawing 19 . As shown in drawing 21 , the image composition section 24 contains the projective-transformation calculation section 231 and the coordinate transformation section 232. Here, the projective-transformation calculation section 231 is connected to the criteria image setting section 20 and the correspondence detecting element 21, and the coordinate transformation section 232 is connected to the criteria image setting section 20, a frame memory 15, and the projective-transformation calculation section 231.

[0107] And the projective-transformation calculation section 231 computes the projective-transformation matrix B shown by the formula (3) using the group of the four or more focus and corresponding points. The calculation procedure is the same as that of the case in the gestalt 1 of the above-mentioned implementation, and should just perform least square count of a formula (5). It is necessary to calculate the projective-transformation matrix between the image pairs of an individual (k-

1) by setting in the gestalt of this operation, and to search for the projective-transformation matrix from each image to a criteria image further here.
[0108] As shown in drawing 18 , more specifically, they are Bn and a projective-transformation matrix from Image imn to Image imj about the projective-transformation matrix from Image imn (n= 1 to k-1) to Image im (n+1) [0109]
[Equation 25]
$B_{n \to j}$

If it sets, this projective-transformation matrix is calculable based on a degree type.
[0110]
[Equation 26]

$$B_{n \to j} = \begin{cases} \prod_{l=n}^{j-1} B_l & (n < j) \\ \left(\prod_{l=j}^{n-1} B_l \right)^{-1} & (n > j) \end{cases} \qquad (26)$$

Here, the coordinate transformation section 232 is stuck [Image / n] in the image [criteria] imj based on the projective-transformation matrix shown by the formula (26) computed by the projective-transformation calculation section 231. Specifically, the coordinate (x y) before the coordinate transformation in Image n corresponding to the coordinate after the coordinate transformation in a criteria image (X, Y) is first calculated based on a degree type.
[0111]
[Equation 27]

$$\begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = s B_{n \to j}^{-1} \begin{bmatrix} X \\ Y \\ 1 \end{bmatrix} \qquad (27)$$

However, s is a constant for setting the third component of the column vector of the left part in a formula (27) to 1. Next, a interpolation operation determines the pixel value of a coordinate (X, Y) based on a pixel value [/ near the coordinate before coordinate transformation (x y)]. And what is necessary is just to perform this interpolation operation using the existing approaches, such as a congruence linear interpolation method and B-spline interpolation method.
[0112] As mentioned above, according to the image processing system 6 concerning the gestalt of this operation, the photographic subject side PL is photoed two or more sheets, and the synthetic image crossed to the large field of the photographic subject side PL is generated by sticking other images to the selected criteria image so that parts may overlap mutually. In this case, by the criteria image setting section 20, since the image photoed from the direction which carries out a right pair mostly to a photographic subject, i.e., the small image of gate distortion, can be chosen as a criteria image, it can instigate as a result and the small overall photographic subject image of distortion can be obtained as the above-mentioned synthetic image.
After setting to the image processing system concerning the gestalten 1 and 2 of the [gestalt 3 of operation] above-mentioned implementation and inputting or photoing two or more photographic subject images previously, the criteria image which is made into the object of distortion amendment or is made into the criteria of a synthetic image is chosen. On the other hand, before the image processing system concerning the gestalt 3 of this operation photos a photographic subject, the above-mentioned criteria image is set up beforehand.
[0113] Drawing 22 is drawing showing the configuration of the image processing system 8 concerning the gestalt 3 of operation of this invention. As shown in drawing 22 , although the image processing

system 8 concerning the gestalt of this operation has the same configuration as the image processing system 1 concerning the gestalt 1 of operation shown in drawing 3 , it is different at the point further equipped with the notice section 26. Here, the notice section 26 is connected to the main control section 14 and the criteria image setting section 20.

[0114] In addition, the shutter 113 and interface 16 which were included in this image processing system 8 are connected to the main control section 14, and a finder 241 is connected to an interface 16.

[0115] Next, actuation of the image processing system 8 concerning the gestalt 3 of operation of this invention is explained, referring to the flow chart of drawing 23 . First, if it is judged whether it instigates in step S1 and amendment mode is chosen, and gate amendment mode is not chosen but the normal mode is chosen, it will progress to step S10 and the snapshot of a desired photographic subject will be taken by the user.

[0116] On the other hand, if it instigates in step S1 and amendment mode is chosen, it will progress to step S2. And in step S2, the image made applicable [of gate distortion] to amendment, i.e., a criteria image, is set as the criteria image setting section 20. The criteria image setting section 20 contains a cursor key 204 and the decision key 203 here, as shown in drawing 24 . And while an overlay indication of the alphabetic character "criteria image setup" is given at a display 17, it points so that the number of sheets photoed to a user after this and the criteria image assignment value which specifies whether the image photographed to the how many sheets in this photography is used as a criteria image may be set up. Here, a user can set up desired photography number of sheets and a criteria image assignment value by making the set point within the limit fluctuate by operating a cursor key 204 top or a down scrolling key by changing between setup of a criteria image to photography number of sheets, and operating the left or a rightward scrolling key. In addition, a setup of the above-mentioned criteria image is completed by pressing the decision key 203.

[0117] Next, in step S3, a user starts photography of the photographic subject image of at least two or more sheets. In addition, at this time, each image needs to be photoed so that parts may overlap mutually. And by supplying a photography signal to the main control section 14 from a shutter 113, whenever it photos an image, the increment of the counter built in the main control section 14 is carried out, and the number-of-sheets specification signal which shows the how many sheets the next photography is from this counter is supplied to the notice section 26. Since the signal which shows the above-mentioned criteria image assignment value from the criteria image setting section 20 is supplied to the register built in the notice section 26 here and the criteria image assignment value is stored in this register, In step S4, the notice section 26 compares the above-mentioned criteria image assignment value always stored in this register with the value which the above-mentioned number-of-sheets specification signal shows, and judges whether the image photoed shortly is what is used as a criteria image.

[0118] And in the above-mentioned comparison, both value is in agreement, when the image which it is going to photo from now on is what is used as a criteria image, it progresses to step S5, and the notice section 26 notifies a user of it being photography of a criteria image. That is, at this time, from the notice section 26, a notice signal is supplied to an interface 16 through the main control section 14, and as shown in drawing 25 , according to this notice signal, the indicator 242 of photographic subject image 35 width in a finder 241 is turned on with an interface 16. Therefore, it is recognized by the user at the time of photography whether it is photography of a criteria image easily. In addition, the notice in the above may be performed by displaying a predetermined text and a predetermined symbol on a display 17 etc.

[0119] Next, although it progresses to step S6, when the image photoed next in step S4 is judged not to consider as a criteria image, it progresses to the direct step S6. And in this step S6, when it is judged whether photography (input of a photographic subject image) of a photographic subject was completed and it is judged that it does not end, it returns to step S3. On the other hand, when it is judged that it ends, it progresses to step S7. Here, it shall be made by pushing the switch with which a setup [in / termination of photography is judged according to directions of a user, and / in these directions / the photography mode setting section 19] was changed to the normal mode, or was prepared for photography termination etc.

[0120] Next, at step S7, the focus is detected in a criteria image and the corresponding points which show the same part as the above-mentioned focus in the image which overlaps in these some criteria images [at least] are detected. Detection of such the focus and corresponding points is performed by the correspondence detecting element 21 shown in drawing 22 . In addition, the configuration and actuation of the this detecting element 21 are the same as that of the case of the gestalt 1 of the above-mentioned implementation.
[0121] And while computing the parameter for amending the gate distortion of a criteria image in step S8, the image which instigated based on the above-mentioned parameter in step S9, and amended distortion is generated, and actuation is ended. In addition, although generation of the image which amended calculation of this parameter and gate distortion is performed by the image-distortion amendment section 22, the configuration and actuation of this image-distortion amendment section 22 are the same as that of the case of the gestalt 1 of the above-mentioned implementation.
[0122] As mentioned above, since a user is notified by the notice section 26 in the image photography by the user by setting up a criteria image assignment value before photography of whether the image photoed next is what is used as a criteria image according to the image processing system 8 concerning the gestalt 3 of this operation, a user can recognize photography of a criteria image easily. And a user can pay [that the field of a request of a photographic subject especially goes into photographic coverage, and] attention at the time of photography of a criteria image. Furthermore, the photography mistake of a criteria image can be decreased.
[0123] In addition, it cannot be overemphasized that the technique which notifies a user of photography of a criteria image according to a setup of a criteria image assignment value by the notice section 26 can be applied also to the image processing system 6 concerning the gestalt 2 of the above-mentioned implementation.
Although the image processing system concerning the gestalt of the [gestalt 4 of operation] above-mentioned implementation needed to photo the photographic subject twice [at least] from a different direction by moving the single optical system included in the image pick-up section, with the image processing system concerning the gestalt of this operation, two or more optical system is installed in the image pick-up section 41 side by side, and two or more sheets are once obtained by photography in the photographic subject image photoed from a different direction.
[0124] Drawing 26 is drawing showing the configuration of the image processing system 40 concerning the gestalt 4 of operation of this invention. As shown in drawing 26 , although the image processing system 40 concerning the gestalt 4 of this operation has the same configuration as the image processing system 1 concerning the gestalt 1 of operation shown in drawing 3 , it is different from the image pick-up section 41 at a point including two optical system 11A and 11B.
[0125] Actuation of the image processing system applied to the gestalt of this operation below is explained referring to the flow chart of drawing 27 . First, an image processing system 40 is started and photography mode is chosen. Here, the above-mentioned photography mode consists of the normal mode which takes the usual snapshot, and gate amendment mode which generates the image which amended the gate distortion of the photoed image. And selection in this photography mode is made when a user operates a photography mode setting key. In addition, as the photography mode setting section 19, the photography mode setting key 104 is formed in the body of an image processing system 40. However, the photography mode setting section 19 may consist of hardware or software etc. which are formed separately from a body.
[0126] And if it is judged whether it instigates in step S1 and amendment mode is chosen, and gate amendment mode is not chosen but the normal mode is chosen as shown in drawing 27 , it will progress to step S10 and the snapshot of a desired photographic subject will be taken by the user.
[0127] The criteria image as an object which instigates in step S1, will progress to step S2 if amendment mode is chosen, instigates to the criteria image setting section 20 on the other hand, and amends distortion is set up. As shown in drawing 28 , the above scrolling key 201 and the down scrolling key 202, and the decision key 203 are contained in the criteria image setting section 20 here. Moreover, a user is asked for selection whether to use as the above-mentioned criteria image the image photoed by

which optical system 11A and 11B while an overlay indication of the alphabetic character "criteria image setup" is given at a display 17.
[0128] Then, by operating the above scrolling key 201 or the down scrolling key 202, a user moves the pointer shown with a triangle on a display 17, and specifies either the display the "camera 1" which chooses optical-system 11A, or the display the "camera 2" which chooses optical-system 11B. And if the above-mentioned pointer presses the decision key 203 where one of optical system is specified, let the image photoed by the this specified optical system be the above-mentioned criteria image. Here, the setting information on the above-mentioned criteria image is supplied to the main control section 14 from the criteria image setting section 20.
[0129] Next, in step S3, a user photos a photographic subject. At this time, it is easily checked [displaying only the image photoed by the optical system chosen at step S2 by control by the main control section 14, then] by the user at a display 17 whether the image which is going to amend gate distortion includes the range of the request of a photographic subject.
[0130] And in step S4, while the focus is detected within a criteria image, the corresponding points which show the same part as this focus within the image which has the field which overlapped the criteria image are detected. In addition, although detection of this focus and corresponding points is performed by the correspondence detecting element 21, the configuration and actuation of this correspondence detecting element 21 are the same as that of the case of the gestalt 1 of the above-mentioned implementation.
[0131] Next, while computing the parameter for amending the gate distortion of a criteria image in step S5, the image which instigated based on this parameter in step S6, and amended distortion is generated, and actuation is ended. Although generation of the image which amended calculation of the above-mentioned parameter and gate distortion is performed by the image-distortion amendment section 22 here, the configuration and actuation of this image-distortion amendment section 22 are the same as that of the case of the gestalt 1 of the above-mentioned implementation.
[0132] As mentioned above, according to the image processing system 40 concerning the gestalt 4 of this operation, since the image pick-up section 41 is equipped with at least two optical system, a user can get the amendment image obtained with the image processing system applied to the gestalt of the above-mentioned implementation by one photography actuation. Moreover, if only the image photoed in the selected optical system is displayed on a display 17, since whether the image which is going to amend gate distortion includes the range of the request of a photographic subject can check easily by the user, a user can pay attention further to photography of a criteria image, and can decrease the possibility of a photography mistake.
[0133] Moreover, it cannot be overemphasized that the image processing system 6 concerning the gestalt 2 of the above-mentioned implementation may be equipped with the image pick-up section which three or more optical system may be included in the image pick-up section 41 shown in drawing 26 , and includes such two or more optical system.
[0134] In addition, in the image processing system concerning the gestalt of implementation of all above, instead of photoing a photographic subject by the image pick-up section, the photographic subject image of two or more sheets stored in storages, such as storage, such as a hard disk, and CD-ROM, may be incorporated in enternal memory section 18 grade, and an amendment image may be generated using these photographic subject images. Moreover, that by which the photography mode setting section 19, the criteria image setting section 20, the correspondence detecting element 21, the image-distortion amendment section 22, and image composition section 24 grade are stored in case with the another image pick-up sections 11 and 41, for example, a computer etc., is considered to be the gestalt of the above-mentioned implementation the same way.
[0135] Moreover, although the correspondence detecting element 21 explained that corresponding points were detected by concentration matching by the correlation technique, you may carry out by another technique, such as a differentiation between space-time. Furthermore, in calculation of a gate distortion parameter, it is not restricted to the coordinate transformation shown in the above formulas (20), but other parameter calculation approaches may be applied.

In the gestalt of the [gestalt 5 of operation] above-mentioned implementation, although the coordinate transformation parameter was computed to the criteria image made into the object of an image processing and the distortion amendment image was generated using the interpolation operation, as for this criteria image, it is desirable that it is the image photoed by an image with little degradation of the image by the interpolation operation, i.e., the condition of having carried out the right pair to the photographic subject comparatively, including abundant paintings-and-calligraphic-works information. Then, the image processing system which performs the image-processing approach which chooses the optimal criteria image as below automatically, and this approach is explained.

[0136] Drawing 29 is drawing showing the first example of a configuration in the image processing system concerning the gestalt 5 of operation of this invention. As shown in drawing 29 , although the image processing system 50 concerning the gestalt 5 of this operation has the same configuration as the image processing system 1 concerning the gestalt 1 of operation shown in drawing 3 , it is different at the point equipped with the photographic subject field judging section 25 and the criteria image automatic selection section 27 instead of the criteria image setting section 20.

[0137] Here, the photographic subject field judging section 25 and the criteria image automatic selection section 27 are connected to the main control section 14, respectively, and the outgoing end of the photographic subject field judging section 25 is connected to the criteria image automatic selection section 27. Moreover, the outgoing end of the criteria image automatic selection section 27 is connected to the image-distortion amendment section 22.

[0138] In addition, also in the image processing system 50 concerning the gestalt 5 of this operation, as shown in drawing 4 , it can consider as the same configuration as the image processing system 1 concerning the gestalt 1 of the above-mentioned implementation.

[0139] It explains referring to the flow chart shown in drawing 30 in actuation of the image processing system 50 applied to the gestalt 5 of this operation below. The image processing system 50 applied to the gestalt 5 of this operation here is explained in detail focusing on difference below in order to operate like the image processing system 1 concerning the gestalt 1 of the above-mentioned implementation.

[0140] First, in step S1, when it is judged whether gate amendment mode is chosen, and gate amendment mode is not chosen but the normal mode is chosen, it progresses to step S10, and a desired snapshot is taken by the user by this user.

[0141] On the other hand, when it instigates by the user in step S1 and amendment mode is chosen, it progresses to step S2. And in step S2, the photographic subject image two-times photography was carried out [the image] at least by the image pick-up section 11 is incorporated to a frame memory 15. In addition, at this time, each image needs to be photoed so that these some photographic subject images may overlap mutually.

[0142] Next, it is judged whether the input of a photographic subject image was completed in step S3, when having not ended, it returns to step S2, and the input of a photographic subject image is continued further. On the other hand, when the input of a photographic subject image is ended with directions of the photography termination by the user, it progresses to step S4.

[0143] And in step S4, the focus is detected by the correspondence detecting element 21 in a photographic subject image, and the corresponding points which show the same part as the above-mentioned focus in the reference image which overlaps in these some photographic subject images [at least] are detected. Next, after detection of the focus and corresponding points is completed, the actuation which instigates below and amends distortion is started. And in step S5, the criteria image automatic selection section 27 makes first automatic selection of the criteria image which is instigated and is made into the object of distortion amendment. The criteria image automatic selection section 27 is explained in detail below.

[0144] In addition, the parameter for instigating in step S6 to the criteria image chosen in step S5 like the image processing system 1 concerning the gestalt 1 of the above-mentioned implementation, and amending distortion is calculated, the image which amended the gate distortion of an image based on this parameter in step S7 is created, and actuation is ended.

[0145] When amending gate distortion, it is suitable, if it crossed to the field where a photographic

subject side is the largest in two or more photoed images, and is reflected as the above-mentioned criteria image and an image with the abundant paintings-and-calligraphic-works amount of information which a user needs is chosen. Moreover, it is suitable if the image with the smallest possible angle (it is also called a "gate angle" to below) made to the photographic subject side of the image pick-up side at the time of photography is chosen. The reason is explained referring to drawing 31 .

[0146] Although the image-distortion amendment section 22 shown in drawing 29 is instigated by performing coordinate transformation by the formula (25) as mentioned above and distortion amendment is performed, this amendment actuation changes according to the gate angle phi. Here, in order to give explanation an easy thing, the gate angle phi is restricted to the circumference of the y-axis, and it is assumed that the magnitude of the plane of projection 31-ed parallel to a photographic subject side is equal to the magnitude of the image pick-up side 32.

[0147] As shown in drawing 31 (a), in the this [angle / phi / gate] coordinate transformation in the case of being comparatively small, the point near the left end of the image pick-up side 32 is projected by the variations shown by the vector which goes to Zero o to the plane of projection 31-ed. In addition, in the slash section in the plane of projection 31-ed, the resolution of a photographic subject image falls by such coordinate transformation.

[0148] On the other hand, as shown in drawing 31 (b), it instigates in this coordinate transformation, and the point near the left end of the image pick-up side 32 is projected on the plane of projection 31-ed with a bigger variations than the variations angle phi is indicated to be to drawing 31 (a) when comparatively large so that the position vector to Zero o may be reduced more greatly. And it turns out that the field to which the resolution of a photographic subject image falls by this coordinate transformation becomes large as compared with the case of drawing 31 (a).

[0149] It turns out that degradation of the resolution which followed, as mentioned above originated in the coordinate transformation by the image-distortion amendment section 22, so that the gate angle phi was small decreases.

[0150] Moreover, although the photographic subject field judging section 25 shown in drawing 29 detects the field which a photographic subject occupies in the photoed image For example, as indicated by reference "processing of an image and recognition" (Takeshi Akoin and Tomoharu Nagao collaboration, Shokodo) (a) How to cluster on an image like a field grown method or a field split plot experiment, (b) The field division approaches using the edge in images, such as the approach of clustering on feature spaces, such as field division by the histogram, and (c) profile line tracking, such as an approach and the (d) texture analysis, are applied. And the photographic subject field judging section 25 chooses the image which photoed the large range of a photographic subject according to this judgment result as the above-mentioned criteria image. Consequently, an image including paintings-and-calligraphic-works information abundant as a criteria image can be chosen automatically.

[0151] The image processing system applied to the gestalt 5 of operation of this invention here can also be considered as a configuration as shown in drawing 32 . That is, although the image processing system 51 shown in drawing 32 has the same configuration as the image processing system 50 shown in drawing 29 , it is different at the point equipped with the straight-line-like pattern detecting element 28 instead of the photographic subject field judging section 25.

[0152] Generally, in the photographic subject side which makes a document the start, many straight-lines [, such as a character string and a ruled line, / which have an parallel relation mutually]-like patterns exist. However, when the gate angle at the time of photography is large, it is projected on an image as a straight-line-like pattern in which the straight-line-like pattern which must originally be parallel has different sense. Therefore, by investigating dispersion in the sense of the straight-line-like pattern projected on the image, the size of this gate angle can be distinguished and an image with a small gate angle can be automatically chosen as a criteria image.

[0153] Here, the straight-line-like pattern detecting element 28 shown in drawing 32 performs processing which detects a straight-line-like pattern in two or more photoed images. And an example of the detection approach of this straight-line-like pattern is explained below.

[0154] First, an edge image is created by taking differential in these two or more images. Next, the

fragmentary edge point group in the created edge image is divided into a straight-line-like segment, and each straight-line-like segment is applied to the straight-line equation shown in the following equations (28).

ax+by+c=0 (a2+b2=1) (28)

here -- the above-mentioned formula (28) -- applying -- it is made by applying a least square method using the point group which constitutes a straight-line-like segment. And termination of the reliance panel of the straight line to a straight-line-like segment searches for dispersion in being a parameter showing the linear sense (a, b). Thus, dispersion in the sense of the straight line in each image can be known by searching for dispersion in the parameter to two or more above-mentioned images of all (a, b). And an image with the smallest dispersion in the linear sense can be automatically chosen as a criteria image.

[0155] Moreover, in automatic selection of a criteria image, the following approaches are also applicable. First, in two or more above-mentioned images, an edge image is created by the same approach as the above. Next, Hough conversion is performed to all the points in this edge image. Hough conversion is mathematical conversion used in order to detect a straight line from a fragmentary edge, and is the space constituted with the parameter of the formula expressing a line to detect here, and the approach of clustering is said. And more specifically, the sequence of points on an image are projected to the theta-rho space shown by the x axis, and angle theta and linear die-length rho to make.

[0156] Drawing 33 is drawing explaining Hough conversion to the theta-rho space shown in drawing 33 (b) from the image space shown in drawing 33 (a). Each point P1-P3 on an image is changed into drawing 33 by Hough conversion at the curves L1-L3 which correspond, respectively so that it may be shown. And although the point CP which the locus of this curve is concentrating in theta-rho space will arise if such conversion is performed about the all points on an image, this point CP is equivalent to the straight line which passes along many edge points in an edge image. If the coordinate of this point CP is set to (theta, rho), it will mean that the straight line corresponding to the following formula (29) was detected here.

Rho=xcostheta+ysintheta (29)

And dispersion in the sense of the straight line in each image can be known by extracting many points CP which this curve concentrates to two or more above-mentioned images of all, and searching for dispersion in theta in these points. Thus, what is necessary is just to choose automatically an image with the smallest dispersion in the linear sense as a criteria image.

[0157] Drawing 34 is drawing showing the third example of a configuration in the image processing system concerning the gestalt 5 of operation of this invention. As shown in drawing 34 , the image processing system concerning the gestalt 5 of this operation is good also as connecting the criteria image automatic selection section 27 to the correspondence detecting element 21, without having the photographic subject field judging section 25 shown in drawing 29 , and the straight-line-like pattern detecting element 28 shown in drawing 32 .

[0158] The group of the focus detected by the detecting element 21 corresponding to the above and corresponding points is used for count of the parameter which amends the projective-transformation matrix B, i.e., gate distortion. At this time, generally, and it is computed with so sufficient that they are distributing broadly a precision. [this parameter] [the group of the above-mentioned focus and corresponding points] Then, the distribution in the groups of the focus detected by the correspondence detecting element 21 and corresponding points and those images may be investigated to two or more photoed images, and the image those values of whose are maxes may be automatically chosen as a criteria image.

[0159] Moreover, in the correspondence detection based on the above-mentioned correlation technique, much focus and corresponding points are detected, so that there are many patterns which generally have the description in an image. And since possibility that many paintings-and-calligraphic-works information useful for a user in an image is included is high, if the focus and corresponding points make automatic selection of the abundant images as a criteria image, that there are many characteristic patterns can instigate an image including required paintings-and-calligraphic-works information, it can

set it as the object of distortion amendment, and is suitable.
[0160] Drawing 35 is drawing showing the fourth example of a configuration in the image processing system concerning the gestalt 5 of operation of this invention. As shown in drawing 35 , the image processing system concerning the gestalt 5 of this operation is good also as having the flat-surface measurement section 29 instead of the photographic subject field judging section 25 shown in drawing 29 , and the straight-line-like pattern detecting element 28 shown in drawing 32 .
[0161] Here, the flat-surface measurement section 29 measures the sense of the photographic subject over the image pick-up section 11 at the time of photography of each image. Drawing 36 is drawing showing the example of a configuration of the flat-surface measurement section 29 shown in drawing 35 . As shown in drawing 36 , the flat-surface measurement section 29 is equipped with the spot light source 271, a photo detector 272, the three-dimension coordinate calculation section 273, and the flat-surface calculation section 274, and the spot light source 271 contains light source 271a which consists of light emitting diode, semiconductor laser, etc., scan mirror 271b, such as a polygon mirror, and mechanical-component 271c which controls a motion of scan mirror 271b.
[0162] Here, in the above-mentioned spot light source 271, scan mirror 271b is controlled by mechanical-component 271c so that the spot light generated by light source 271a hits the photographic subject side PL. Moreover, a photo detector 272 is constituted by optoelectric transducers by which the location to the spot light source 271 was installed in the location measured beforehand, such as PSD (Position sensitive detector) and CCD, and detects the sense of the reflected light from the photographic subject side PL. In addition, the optoelectric transducer 114 contained in the image pick-up section 11 may be used as a photo detector 272 in the above.
[0163] Moreover, the three-dimension coordinate calculation section 273 computes the three-dimension coordinate (X, Y, Z) of the photographic subject side PL on the basis of an image processing system 53 by using the principle of triangulation according to the sense of spot light which the spot light source 271 irradiated, and the physical relationship of the spot light source 271 and a photo detector 272 and the sense of the reflected light which the photo detector 272 detected. And the flat-surface calculation section 274 presumes a flat-surface equation using the three-dimension coordinate of three or more points which is not on the same straight line computed by the three-dimension coordinate calculation section 273. For example, it is the flat-surface equation for which it asks aX+bY+cZ+d=0 (a2+b2+c2=1, c> 0) (30)
It sets and four parameters (a, b, c, d) in the above-mentioned flat-surface equation are calculated with a least square method using the three-dimension coordinate of three or more points. Consequently, the above-mentioned gate angle phi is calculated by the degree type (31).
Phi=cos - 1c (31)
Therefore, what is necessary is to measure the sense of a photographic subject side to two or more photoed images of all, and just to choose automatically the image the gate angle phi of whose is min as a criteria image.
[0164] In addition, as described in explanation of the image-distortion amendment section 22, it can ask for the sense of this photographic subject also by using the group of the focus and corresponding points which were detected by the correspondence detecting element 21. Therefore, the image processing system concerning the gestalt 5 of this operation can once perform a formula (14) thru/or a formula (18) in the image-distortion amendment section 22, can ask for the sense of a photographic subject, and can also consider the obtained result as the configuration of outputting to the criteria image automatic selection section 27.
As shown below in [the gestalt 6 of operation] at drawing 18 , the gestalt of the operation on condition of the case where the static image in the same photographic subject side PL is photoed from two or more directions so that it may overlap in some images, respectively is explained. In addition, as shown in drawing 18 here, by Hazama of Image imj and Image im (j+1) (1 <=j<=K -1) which were obtained by taking a photograph in the direction which Image imj (1 <=j<=K) is obtained, for example, adjoins each other like an image im1 and an image im2, there shall be a duplication field by taking a photograph from Direction dj, respectively. And in the image processing system concerning the gestalt 6 of this operation,

other images are stuck and a synthetic image is generated so that it may have consistency in the gap or one image chosen as a criteria image.
[0165] Drawing 37 is drawing showing the configuration of the image processing system 60 concerning the gestalt 6 of operation of this invention. As shown in drawing 37 , although the image processing system 60 concerning the gestalt 6 of this operation has the same configuration as the image processing system 6 concerning the gestalt 2 of operation shown in drawing 19 , it is different at the point equipped with the criteria image automatic selection section 27 instead of the criteria image setting section 20.
[0166] The image processing system 60 concerning the gestalt 6 of this operation which has the above configurations is explained focusing on difference, referring to the flow chart shown in drawing 38 in actuation of the image processing system 60 applied to the gestalt 6 of this operation below, although it operates like the image processing system 6 concerning the gestalt 2 of operation.
[0167] First, in step S1, when it is judged whether image composition mode is chosen, and image composition mode is not chosen but the normal mode is chosen, it progresses to step S10, and a desired snapshot is taken by the user by this user.
[0168] On the other hand, when image composition mode is chosen by the user in step S1, it progresses to step S2. And in step S2, two or more photographic subject images photoed by the image pick-up section 11 are incorporated to a frame memory 15. In addition, at this time, each image needs to be photoed so that these some photographic subject images may overlap mutually.
[0169] Next, it is judged whether the input of a photographic subject image was completed in step S3, when having not ended, it returns to step S2, and the input of a photographic subject image is continued further. On the other hand, when the input of a photographic subject image is ended with directions of the photography termination by the user, it progresses to step S4.
[0170] And in step S4, the focus is detected by the correspondence detecting element 21 between Image imj and Image im (j+1), and the corresponding points which show the same part as the above-mentioned focus in the image im (j+1) which overlaps in these some images [at least] imj are detected.
[0171] Next, after detection of this focus and these corresponding points is completed, the actuation which generates the synthetic image which stuck the image of two or more sheets on below is started. And in step S5, the criteria image automatic selection section 27 chooses automatically first the criteria image made into criteria in this composition. Here, the criteria image automatic selection section 27 chooses automatically the image with the above-mentioned smallest possible gate angle as a criteria image. And the synthetic small image of gate distortion can be obtained by performing such selection.
[0172] And in step S6, the projective-transformation matrix for performing composition on the basis of the criteria image chosen in step S5 is computed, a synthetic image is generated using this projective-transformation matrix in step S7, and actuation is ended.
[Gestalt 7 of operation] drawing 39 is drawing showing the configuration of the image processing system concerning the gestalt 7 of operation of this invention. As shown in drawing 39 , although the image processing system 70 concerning the gestalt 7 of this operation has the same configuration as the image processing system 1 concerning the gestalt 1 of operation shown in drawing 3 , it is different at the point further equipped with the criteria image automatic selection section 27 and the change section 45.
[0173] Here, the criteria image automatic selection section 27 is controlled by the main control section 14. Moreover, as for the change section 45, an outgoing end is connected to the image-distortion amendment section 22 while the input edge is connected to the criteria image setting section 20 and the criteria image automatic selection section 27.
[0174] Moreover, the change section 45 changes the selection approach of a criteria image, and as shown in drawing 40 , it contains the above scrolling key 201, the down scrolling key 202, and the decision key 203. Here, when a user pushes alternatively the menu screen key (not shown) displayed on a display 17, the screen where an overlay indication of the alphabetic character "selection of a criteria image" as shown in drawing 40 was given is displayed on a display 17.
[0175] And when the above scrolling key 201 or the down scrolling key 202 is operated by this user, the cursor of the triangle shown in drawing 40 carries out vertical migration. At this time, if the decision key

203 is pressed in the condition that this cursor has pointed out the alphabetic character of "AUTO", the criteria image automatic selection section 27 as which choosing a criteria image automatically was determined and it was indicated to be to drawing 39 will be activated alternatively. On the other hand, if the decision key 203 is pressed in the condition that this cursor has pointed out the alphabetic character of "MANUAL", the criteria image setting section 20 as which setting up a criteria image with hand control was determined, and it was indicated to be to drawing 39 will be activated alternatively.
[0176] Therefore, according to the image processing system concerning the gestalt 7 of this operation, by the change by the change section 45, since either the criteria image setting section 20 or the criteria image automatic selection section 27 is alternatively connectable with the image-distortion amendment section 22, a user can choose automatic or manual either as arbitration as the selection approach of a criteria image.
[0177] In addition, also in the gestalt of which operation mentioned above, the image-processing approach concerning the gestalt of this operation can be described as a computer program. And as shown in drawing 41 , the above-mentioned image processing is easily realizable by equipping an image processing system 1 with the record medium 301 which stored this program, and making an image processing system 1 perform this program.
[0178] Moreover, as shown in drawing 42 , the above-mentioned image processing is realizable also by equipping a personal computer (personal computer) PC with CD-ROM302 which stored this program, and performing this program with a personal computer PC. In addition, as a record medium with which a personal computer PC is equipped and which stores this program, it is not restricted to above-mentioned CD-ROM302, for example, it cannot be overemphasized that you may be DVD-ROM etc.
[0179] An example in case this program execution realizes the above-mentioned image-processing approach below is explained. In this case, an image processing system 1 and a personal computer PC are incorporated to the above-mentioned signal-processing section 12 through the various interfaces in which the photographic subject image of two or more sheets stored in record media, such as storage, such as built-in memory and a hard disk, and CD-ROM, was carried by the computer.
[0180] Moreover, a setup in the photography mode in the above is carried out by carrying out the mouse click of the icon displayed on push or a screen in the predetermined key in the keyboard of a personal computer PC. The image by which infanticide was carried out [above-mentioned] on the other hand by operating on a curtailed schedule and displaying two or more inputted images on a screen, pushing the vertical cursor key of the keyboard used for a calculating machine, or clicking on an icon with a mouse in choosing a criteria image with hand control etc. is chosen. And if a line feed key is pressed where a desired image is chosen, this image will be set up as a criteria image.
[0181] Moreover, about the focal distance f of the optical system which constitutes the image pick-up section 11, the focal distance of this optical system is measured beforehand, and it records on the interior of this record medium. And a user chooses the focal distance of the optical system used on the screen on the occasion of actual photography. Here, this focal distance is also recordable as header information. That is, when using an Exif format, for example as image data, the focal distance at the time of photography can be recorded as the header information. And the image processing system concerning the gestalt of this operation can obtain this focal distance by reading this header information. In addition, when the above approaches cannot be taken, it is good to display a dialog box etc. on screens, such as a personal computer PC, and to make a user do the manual entry of the direct focal distance into this dialog box.
[0182] Moreover, it can treat about direction of the photographic subject in the above as well as the above-mentioned focal distance. That is, the sense of the photographic subject measured by the flat-surface measurement section 29 or the image-distortion amendment section 22 is beforehand recorded as header information in an image data file, and the image processing system concerning the gestalt of this operation is good also as obtaining the sense of this photographic subject by reading this header information.
[0183] Although the field for recording the sense of a photographic subject does not exist in using an Exif format as this time, for example, image data, the sense of a photographic subject is recordable on

the field which the manufacturer called Maker Note can use freely.
[0184] Moreover, when the above approaches cannot be taken, it is good to display a dialog box etc. on screens, such as a personal computer PC, and to make it make a user input the sense of a direct photographic subject like the case of a focal distance.
[0185] In addition, the gestalt of operation of above-mentioned this invention can be applied to image processings using a digital still camera or a digital camcorder, such as a space information input and lamination composition of a division image, and can be applied also to the image device of a non-contact handy scanner or others.
[Effect of the Invention] Since the image optimal in order to obtain a proper image by choosing the object which amends distortion out of two or more images in the image-processing approach which amends distortion of the image photoed from two or more directions can be made applicable to amendment like **** according to this invention so that at least a part may overlap to a photographic subject, this more accurate amendment is realizable.
[0186] Moreover, distortion chooses fewest images from two or more images, and if the image which amended distortion is compounded with the this chosen image, a more proper synthetic image can be obtained.
[0187] Here, if the object of amendment is automatically chosen according to the size of the field which a photographic subject occupies into an image, since the paintings-and-calligraphic-works amount of information needed can amend distortion of the most abundant images automatically, a certainly proper image can be obtained.
[0188] Moreover, if the object of amendment is automatically chosen according to the sense of the straight-line-like pattern detected in an image, since the image photoed from the location which carried out the right pair to the photographic subject mostly can be automatically made applicable to amendment, a proper image with high resolution can be obtained.
[0189] Moreover, if the object of amendment is automatically chosen according to the specified correspondence relation, since high amendment of precision can be performed certainly, the dependability of an image processing can be raised.
[0190] Moreover, if the object of amendment is automatically chosen according to the sense of the photographic subject detected for every photography, since the image photoed from the location which carried out the right pair mostly to the photographic subject can be automatically made applicable to amendment, a proper image with high resolution can be obtained.
[0191] Moreover, since according to the image processing system equipped with a notice means to notify a user of becoming the image made into the criteria at the time of the image photoed next amending distortion attention is called in the photography of an image made into criteria to a user in case distortion is amended, the photography mistake by a user's inattention etc. is avoided and dependability of operation and the quality of an amendment image can be raised.
[0192] Moreover, according to the image processing system equipped with two or more optical means which photo a photographic subject to coincidence, and a selection means to choose the image made into the object of amendment among the images photoed by two or more optical means Since two or more photographic subject images once photoed by photography from two or more directions can be obtained, while actuation is made simple by decreasing the count of photography needed in order to amend distortion, the image with which distortion amendment was carried out more simply can be obtained.

[Translation done.]

(19)日本国特許庁（ＪＰ）　(12)公開特許公報（Ａ）　(11)特許出願公開番号
特開2001－250114
（P2001－250114A）
(43)公開日　平成13年９月14日(2001.9.14)

(51)Int.Cl.'		識別記号	FI		テーマコード'（参考）
Ｇ０６Ｔ	3/00	２００	Ｇ０６Ｔ 3/00	２００	５Ｂ０５７
		４００		４００Ｊ	５Ｃ０２３
Ｈ０４Ｎ	1/387		Ｈ０４Ｎ 1/387		５Ｃ０７６
	5/262		5/262		

審査請求　未請求　請求項の数16　ＯＬ　（全 39 頁）

(21)出願番号　特願2000－261565(P2000－261565)
(22)出願日　平成12年８月30日(2000.8.30)
(31)優先権主張番号　特願平11－375651
(32)優先日　平成11年12月28日(1999.12.28)
(33)優先権主張国　日本（ＪＰ）

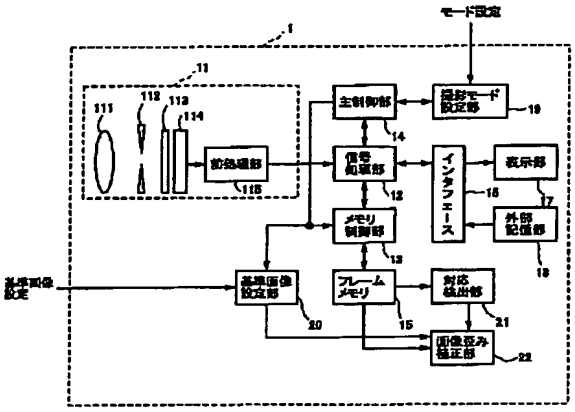
(71)出願人　000006747
株式会社リコー
東京都大田区中馬込１丁目３番６号
(72)発明者　村田　憲彦
東京都大田区中馬込１丁目３番６号　株式会社リコー内
(72)発明者　北口　貴史
東京都大田区中馬込１丁目３番６号　株式会社リコー内
(74)代理人　100070150
弁理士　伊東　忠彦

最終頁に続く

(54)【発明の名称】　画像処理方法と画像処理装置及びコンピュータ読み取り可能な記録媒体

(57)【要約】
【課題】　歪みを補正してより適正な画像を容易に得るための画像処理方法と画像処理装置、及び該方法を実現するための記録媒体を提供する。
【解決手段】　被写体に対して少なくとも一部が重複するよう複数の方向から撮影された画像の歪みを補正する画像処理装置１であって、撮影により得られた複数の画像内における重複部分の対応関係を検出する対応検出部２１と、複数の画像の中から歪みを補正する対象を選択する基準画像設定部２０と、対応検出部２１により検出された対応関係に応じて、基準画像設定部２０により設定された画像の歪みを補正する画像歪み補正部２２とを備えたことを特徴とする画像処理装置１を提供する。

本発明の実施の形態1に係る画像処理装置の構成を示す図



1

【特許請求の範囲】

【請求項１】　被写体に対して少なくとも一部が重複するよう複数の方向から撮影された画像の歪みを補正する画像処理方法であって、
前記撮影により得られた複数の前記画像内における重複部分の対応関係を特定する第一のステップと、
前記複数の画像の中から前記歪みを補正する対象を選択する第二のステップと、
前記第一のステップにおいて特定された前記対応関係に応じて、前記第二のステップで選択された前記画像の前記歪みを補正する第三のステップとを有することを特徴とする画像処理方法。

【請求項２】　前記第二のステップでは、前記画像内において前記被写体が占める領域の広さに応じて前記補正の対象を自動的に選択する請求項１に記載の画像処理方法。

【請求項３】　前記第二のステップでは、前記画像内において検出される直線状パターンの向きに応じて前記補正の対象を自動的に選択する請求項１に記載の画像処理方法。

【請求項４】　前記第二のステップでは、前記第一のステップにおいて特定された前記対応関係に応じて前記補正の対象を自動的に選択する請求項１に記載の画像処理方法。

【請求項５】　前記第二のステップでは、前記撮影毎に検出された前記被写体の向きに応じて前記補正の対象を自動的に選択する請求項１に記載の画像処理方法。

【請求項６】　被写体に対して少なくとも一部が重複するよう複数の方向から撮影された画像の歪みを補正する画像処理方法であって、
前記撮影により得られた複数の前記画像内における重複部分の対応関係をそれぞれ特定する第一のステップと、
前記複数の画像の中から前記歪みが最も少ない前記画像を選択する第二のステップと、
前記第一のステップにおいて特定された前記対応関係に応じて、前記複数の画像の前記歪みをそれぞれ補正し、
前記第二のステップにおいて選択された前記画像と合成する第三のステップとを有することを特徴とする画像処理方法。

【請求項７】　被写体に対して少なくとも一部が重複するよう複数の方向から撮影された画像の歪みを補正する画像処理装置であって、
前記撮影により得られた複数の前記画像内における重複部分の対応関係を検出する対応検出手段と、
前記複数の画像の中から前記歪みが最も少ない前記画像を選択する選択手段と、
前記対応検出手段において検出された前記対応関係に応じて、前記複数の画像の前記歪みをそれぞれ補正し、前記選択手段において選択された前記画像と合成する画像合成手段とを備えたことを特徴とする画像処理装置。

2

【請求項８】　被写体に対して少なくとも一部が重複するよう複数の方向から撮影された画像の歪みを補正する画像処理装置であって、
これから撮影する複数の前記画像のうち、前記歪みを補正する際の基準とする前記画像を予め選択する選択手段と、
前記選択手段によりなされた前記選択に応じて、次に撮影する前記画像が前記基準とされる前記画像となることをユーザへ通知する通知手段と、
撮影することにより得られた前記基準とされる前記画像と他の前記画像との間における重複部分の対応関係を検出する対応検出手段と、
前記対応検出手段により検出された前記対応関係に応じて、前記基準とされる前記画像の前記歪みを補正する補正手段とを備えたことを特徴とする画像処理装置。

【請求項９】　被写体に対して少なくとも一部が重複するよう複数の方向から撮影された画像の歪みを補正する画像処理装置であって、
前記撮影により得られた複数の前記画像内における重複部分の対応関係を検出する対応検出手段と、
前記複数の画像の中から前記歪みを補正する対象を選択する選択手段と、
前記対応検出手段により検出された前記対応関係に応じて、前記選択手段により選択された前記画像の前記歪みを補正する補正手段とを備えたことを特徴とする画像処理装置。

【請求項１０】　被写体に対して少なくとも一部が重複するよう複数の方向から撮影された画像の歪みを補正する画像処理装置であって、
前記被写体を同時に撮影する複数の光学手段と、
前記複数の光学手段で撮影される前記画像のうち前記補正の対象とする前記画像を選択する選択手段と、
前記選択手段により選択された前記画像と他の前記画像との間における重複部分の対応関係を検出する対応検出手段と、
前記対応検出手段により検出された前記対応関係に応じて、前記選択された画像の前記歪みを補正する補正手段とを備えたことを特徴とする画像処理装置。

【請求項１１】　前記選択手段は、前記画像内において前記被写体が占める領域の広さに応じて前記補正の対象を自動的に選択する請求項９又は１０に記載の画像処理装置。

【請求項１２】　前記選択手段は、前記画像内において検出される直線状パターンの向きに応じて前記補正の対象を自動的に選択する請求項９又は１０に記載の画像処理装置。

【請求項１３】　前記選択手段は、前記対応検出手段により検出された前記対応関係に応じて前記補正の対象を自動的に選択する請求項９に記載の画像処理装置。

【請求項１４】　前記選択手段は、前記撮影毎に検出さ

れた前記被写体の向きに応じて前記補正の対象を自動的に選択する請求項９又は１０に記載の画像処理装置。

【請求項１５】　被写体に対して少なくとも一部が重複するよう複数の方向から撮影された画像の歪みをコンピュータにより補正するためのプログラムを記録したコンピュータ読み取り可能な記録媒体であって、前記プログラムは、

前記コンピュータに対し、前記撮影により得られた複数の前記画像内における重複部分の対応関係を特定させ、

前記複数の画像の中から前記歪みを補正する対象を選択させ、

特定された前記対応関係に応じて、選択された前記画像の前記歪みを補正させることを特徴とするコンピュータ読み取り可能な記録媒体。

【請求項１６】　被写体に対して少なくとも一部が重複するよう複数の方向から撮影された画像の歪みをコンピュータにより補正するためのプログラムを記録したコンピュータ読み取り可能な記録媒体であって、前記プログラムは、

前記コンピュータに対し、前記撮影により得られた複数の前記画像内における重複部分の対応関係をそれぞれ特定させ、

前記複数の画像の中から前記歪みが最も少ない前記画像を選択させ、

特定された前記対応関係に応じて、前記複数の画像の前記歪みをそれぞれ補正させて、選択された前記画像と合成させることを特徴とするコンピュータ読み取り可能な記録媒体。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は画像処理方法と画像処理装置及び記録媒体に関し、さらに詳しくは、撮影状態によらず適正な画像を得るための画像処理方法と画像処理装置、及び該画像処理方法を実現するためのコンピュータ読み取り可能な記録媒体に関するものである。

【０００２】

【従来の技術】コンピュータネットワークの急速な進歩と共にビジネスのあり方も多様化し、あらゆる局面で重要な情報を素早く取得する必要が生じている。それに伴い、至る所で携帯型の入力装置を駆使してビジネスに必要な商品や文書情報を簡便かつ高精細に入力することへの要求が高まっている。特に、デジタルスチルカメラの急速な普及及びその高解像化に伴い、撮影した画像に加工・処理を施すことにより、仕事や娯楽に有効な電子情報として活用しようという応用例も見られるようになった。

【０００３】代表的な第一の応用例としては、Ａ４紙面や大型のポスター等の被写体面を撮影するとき、撮像面と被写体面が平行でない状態で撮影した場合には、画像の歪み（これを「あおり歪み」ともいう。）が生じるが、これを補正することによって取得した文書画像情報の判読性を向上させる技術がある。ここで、「あおり歪み」を補正したい画像においては、被写体の所望の範囲が写されていることが要求される。すなわち、ユーザは撮影した複数枚の画像のうち少なくとも１枚は被写体の所望の範囲が含まれるように撮影する必要がある。従って、撮影した複数枚の画像のうちあおり歪みを補正する対象を選択できるインタフェース（Ｉ／Ｆ）や、撮影時にユーザへ相応の注意を促すインタフェースが望まれている。

【０００４】また、第二の応用例としては、携帯可能な画像入力装置で新聞紙等の大面積の紙面情報やパネルや壁に描かれた絵柄等を分割撮影して、得られた複数枚の画像を貼り合わせることにより１枚の合成画像を作成するものがある。すなわち、ＣＣＤ（Charge Coupled Device）に代表される撮像素子の画素数増加に伴い、デジタルカメラの解像度は近年向上しているが、上記のように細かいパターンを有する被写体、すなわち高い周波数成分を含む被写体を撮影して電子化するにはまだまだ解像度が不足する。従って、画像を貼り合わせることにより擬似的に高精細画像を作成して、デジタルカメラの解像度不足を補うというアプローチがなされている。

【０００５】このような応用例は、被写体が平面状とみなせる場合にアフィン変換や射影変換のような幾何補正式を用いて、被写体の一部分を分割撮影した画像を貼り合わせる技術であり、各分割画像の被写体像を基準となる画像における被写体の見え方に変換して貼り合わせるというものである。なお、このような技術の概要は文献『コンピュータビジョン－技術評論と将来展望－』（松山隆司ほか、新技術コミュニケーションズ）に記載されている。

【０００６】しかしながら、このような応用例において、基準となる画像において被写体像にあおり歪みが生じていた場合には、貼り合わせた合成画像においてもあおり歪みが含まれてしまうという問題がある。すなわち、分割的に撮影して得られた複数の画像のうち、どの画像を基準にして貼り合わせを実行するかによって、生成される合成画像におけるあおり歪みの大きさが変化する。この問題について図１を参照しつつ説明する。

【０００７】図１（ａ）に示されるように、例えばある被写体面ＰＬを三方向D_1～D_3から撮影し、それぞれ画像ＩＭ１～ＩＭ３が得られたとき、被写体面ＰＬに対して左斜め方向から撮影して得られた画像ＩＭ１を基準にしてこれら三つの画像を貼り合わせると、図１（ｂ）に示されるような合成画像ＩＭＡが得られる。また、ほぼ正面方向から撮影した画像ＩＭ２を基準にして同様に貼り合わせると、図１（ｃ）に示されるような合成画像ＩＭＢが得られる。ここで、図１（ｂ）及び図１（ｃ）に示されるように、上記の両合成画像ＩＭＡ，ＩＭＢは、あおり歪みの大きさが大きく異なる。

【０００８】従って、撮影した複数枚の画像のうち少なくとも１枚は被写体面ＰＬにほぼ正対して撮影されたものであることが望まれるため、撮影された複数枚の画像のうち貼り合わせの際に基準とする画像を選択するインタフェース、及びその貼り合わせの基準となる画像を撮影する時にユーザに注意を促すインタフェースが望まれている。

【０００９】

【発明が解決しようとする課題】本発明は、上述の点に鑑みてなされたものであり、歪みを補正してより適正な画像を容易に得るための画像処理方法と画像処理装置、及び該画像処理方法を実現するためのコンピュータ読み取り可能な記録媒体を提供することを目的とする。

【００１０】

【課題を解決するための手段】上記の目的は、被写体に対して少なくとも一部が重複するよう複数の方向から撮影された画像の歪みを補正する画像処理方法であって、撮影により得られた複数の画像内における重複部分の対応関係を特定する第一のステップと、複数の画像の中から歪みを補正する対象を選択する第二のステップと、第一のステップにおいて特定された対応関係に応じて、第二のステップで選択された画像の歪みを補正する第三のステップとを有することを特徴とする画像処理方法を提供することにより達成される。このような手段によれば、歪みを補正する対象が選択されるため、適正な画像を得るために最適な画像を補正対象とすることができる。

【００１１】ここで、第二のステップでは、画像内において被写体が占める領域の広さに応じて補正の対象を自動的に選択するようにしてもよい。このような手段によれば、必要とされる書画情報量が最も豊富な画像の歪みを自動的に補正することができる。

【００１２】また、第二のステップでは、画像内において検出される直線状パターンの向きに応じて補正の対象を自動的に選択するようにしてもよい。このような手段によれば、被写体にほぼ正対した位置から撮影された画像を自動的に補正対象とすることができる。

【００１３】また、第二のステップでは、第一のステップにおいて特定された対応関係に応じて補正の対象を自動的に選択するようにすれば、精度の高い補正を確実に実行することができる。

【００１４】また、第二のステップでは、撮影毎に検出された被写体の向きに応じて補正の対象を自動的に選択するようにすれば、被写体に対してほぼ正対した位置から撮影された画像を自動的に補正対象とすることができる。

【００１５】また、本発明の目的は、被写体に対して少なくとも一部が重複するよう複数の方向から撮影された画像の歪みを補正する画像処理方法であって、撮影により得られた複数の画像内における重複部分の対応関係をそれぞれ特定する第一のステップと、複数の画像の中から歪みが最も少ない画像を選択する第二のステップと、第一のステップにおいて特定された対応関係に応じて、複数の画像の歪みをそれぞれ補正し、第二のステップにおいて選択された画像と合成する第三のステップとを有することを特徴とする画像処理方法を提供することにより達成される。このような手段によれば、歪みが最も少ない画像を基準に合成画像が生成されるため、より適正な合成画像を得ることができる。

【００１６】また、本発明の目的は、被写体に対して少なくとも一部が重複するよう複数の方向から撮影された画像の歪みを補正する画像処理装置であって、撮影により得られた複数の画像内における重複部分の対応関係を検出する対応検出手段と、複数の画像の中から歪みが最も少ない画像を選択する選択手段と、対応検出手段において検出された対応関係に応じて、複数の画像の歪みをそれぞれ補正し、選択手段において選択された画像と合成する画像合成手段とを備えたことを特徴とする画像処理装置を提供することにより達成される。

【００１７】また、本発明の目的は、被写体に対して少なくとも一部が重複するよう複数の方向から撮影された画像の歪みを補正する画像処理装置であって、これから撮影する複数の画像のうち、歪みを補正する際の基準とする画像を予め選択する選択手段と、選択手段によりなされた選択に応じて、次に撮影する画像が基準とされる画像となることをユーザへ通知する通知手段と、撮影することにより得られた基準とされる画像と他の画像との間における重複部分の対応関係を検出する対応検出手段と、対応検出手段により検出された対応関係に応じて、基準とされる画像の歪みを補正する補正手段とを備えたことを特徴とする画像処理装置を提供することにより達成される。このような手段によれば、歪みを補正する際の基準とする画像の撮影において、ユーザへ注意を喚起できる。

【００１８】また、本発明の目的は、被写体に対して少なくとも一部が重複するよう複数の方向から撮影された画像の歪みを補正する画像処理装置であって、撮影により得られた複数の画像内における重複部分の対応関係を検出する対応検出手段と、複数の画像の中から歪みを補正する対象を選択する選択手段と、対応検出手段により検出された対応関係に応じて、選択手段により選択された画像の歪みを補正する補正手段とを備えたことを特徴とする画像処理装置を提供することにより達成される。

【００１９】また、本発明の目的は、被写体に対して少なくとも一部が重複するよう複数の方向から撮影された画像の歪みを補正する画像処理装置であって、被写体を同時に撮影する複数の光学手段と、複数の光学手段で撮影される画像のうち補正の対象とする画像を選択する選択手段と、選択手段により選択された画像と他の画像との間における重複部分の対応関係を検出する対応検出手

段と、対応検出手段により検出された対応関係に応じて、選択された画像の歪みを補正する補正手段とを備えたことを特徴とする画像処理装置を提供することにより達成される。このような手段によれば、一度の撮影により複数の方向から撮影された複数の被写体像を得ることができるため、歪みを補正するために必要とされる撮影回数を減らすことができる。

【００２０】ここで、選択手段は、画像内において被写体が占める領域の広さに応じて補正の対象を自動的に選択するものとし、あるいは、画像内において検出される直線状パターンの向きに応じて補正の対象を自動的に選択するものとすることができる。また、選択手段は、対応検出手段により検出された対応関係に応じて補正の対象を自動的に選択するものとし、あるいは、撮影毎に検出された被写体の向きに応じて補正の対象を自動的に選択するものとしてもよい。

【００２１】また、本発明の目的は、被写体に対して少なくとも一部が重複するよう複数の方向から撮影された画像の歪みをコンピュータにより補正するためのプログラムを記録したコンピュータ読み取り可能な記録媒体であって、該プログラムは、コンピュータに対し、撮影により得られた複数の画像内における重複部分の対応関係を特定させ、複数の画像の中から歪みを補正する対象を選択させ、特定された対応関係に応じて、選択された画像の歪みを補正させることを特徴とするコンピュータ読み取り可能な記録媒体を提供することにより達成される。このような手段によれば、適正な画像を得るために最適な画像を容易に補正対象とすることができる。

【００２２】また、本発明の目的は、被写体に対して少なくとも一部が重複するよう複数の方向から撮影された画像の歪みをコンピュータにより補正するためのプログラムを記録したコンピュータ読み取り可能な記録媒体であって、該プログラムは、コンピュータに対し、撮影により得られた複数の画像内における重複部分の対応関係をそれぞれ特定させ、複数の画像の中から歪みが最も少ない画像を選択させ、特定された対応関係に応じて、複数の画像の歪みをそれぞれ補正させて、選択された画像と合成させることを特徴とするコンピュータ読み取り可能な記録媒体を提供することにより達成される。このような手段によれば、より適正な合成画像を容易に得ることができる。

【００２３】

【発明の実施の形態】以下において、本発明の実施の形態を図面を参照して詳しく説明する。なお、図中同一符号は同一又は相当部分を示す。

［実施の形態１］図２は、本発明の実施の形態１に係る画像処理方法及び画像処理装置を説明するための図である。ここで、本実施の形態においては、図２に示されるように、画像処理装置１により被写体面ＰＬの少なくとも一部が重複するよう２枚の画像３，４が撮影され、これら２枚の画像３，４のうちいずれか一方、例えば画像３のあおり歪みを補正して最終的に歪み補正画像５を得るという例により説明される。

【００２４】図３は、本発明の実施の形態１に係る画像処理装置１の構成を示す図である。図３に示されるように、画像処理装置１は撮像部１１と、信号処理部１２と、メモリ制御部１３と、主制御部１４と、フレームメモリ１５と、インタフェース１６と、表示部１７と、外部記憶部１８と、撮影モード設定部１９と、基準画像設定部２０と、対応検出部２１と、画像歪み補正部２２とを備える。そして、撮像部１１はレンズ１１１と、絞り１１２と、シャッター１１３と、光電変換素子１１４と、前処理部１１５とを含む。

【００２５】ここで、信号処理部１２は、前処理部１１５とメモリ制御部１３、主制御部１４及びインタフェース１６に接続される。また、メモリ制御部１３はさらにフレームメモリ１５と基準画像設定部２０に接続される。主制御部１４はさらに、メモリ制御部１３と撮影モード設定部１９及び基準画像設定部２０に接続される。

【００２６】またフレームメモリ１５は、メモリ制御部１３と対応検出部２１及び画像歪み補正部２２に接続される。また、インタフェース１６はさらに表示部１７及び外部記憶部１８に接続される。そして、基準画像設定部２０はさらに画像歪み補正部２２に接続される。また、対応検出部２１はさらに画像歪み補正部２２に接続される。

【００２７】一方、撮像部１１においては、レンズ１１１と絞り１１２、シャッター１１３、光電変換素子１１４が光軸上でこの順に配置され、光電変換素子１１４は前処理部１１５に接続される。

【００２８】上記において、撮影モード設定部１９により撮影モードが切り替えられ、基準画像設定部２０であおり歪みを補正する画像が設定される。また対応検出部２１は、少なくとも一部が相互に重複した二つの画像において、両画像間の特徴点及び対応点を抽出する。そして、画像歪み補正部２２は対応検出部２１から供給された信号に応じて、撮影した画像におけるあおり歪みを補正する。なお、上記における基準画像の設定や対応検出部２１の動作、あおり歪みの補正については、後において詳しく説明する。

【００２９】また、撮像部１１の光電変換素子１１４には例えばＣＣＤが使用される。また、前処理部１１５にはプリアンプや自動利得制御回路（Auto Gain Control－AGC）等からなるアナログ信号処理部やアナログ－デジタル変換器（Ａ／Ｄ変換器）が備えられ、光電変換素子１１４より出力されたアナログ映像信号に対して、増幅やクランプ等の前処理が施された後、上記アナログ映像信号がデジタル映像信号に変換される。

【００３０】また、信号処理部１２はデジタル信号処理プロセッサ（DSPプロセッサ）等により構成され、撮像

部１１において得られたデジタル映像信号に対して色分解、ホワイトバランス調整、γ補正など種々の画像処理を施す。また、メモリ制御部１３はこのようにして処理された画像信号をフレームメモリ１５へ格納したり、逆にフレームメモリ１５に格納された画像信号を読み出す。また、主制御部１４はマイコンなどにより構成される。また、フレームメモリ１５は少なくとも２枚の画像を格納し、一般的にはVRAM、SRAM、DRAM等の半導体メモリが使用される。

【００３１】ここで、フレームメモリ１５から読み出された画像信号は、信号処理部１２において画像圧縮等の信号処理が施された後、インタフェース１６を介して外部記憶部１８に保存される。この外部記憶部１８はインタフェース１６を介して供給される画像信号などの種々の信号を読み書きし、ＩＣメモリカードや光磁気ディスク等により構成される。ここで外部記憶部１８として、モデムカードやＩＳＤＮカードが使用されれば、ネットワークを経由して画像信号を直接遠隔地の記録媒体に送信することもできる。

【００３２】また、逆に外部記憶部１８に記録された画像信号の読み出しは、インタフェース１６を介して信号処理部１２へ画像信号が送信され、信号処理部１２において画像伸長が施されることによって行われる。一方、外部記憶部１８及びフレームメモリ１５から読み出された画像信号の表示は、信号処理部１２において画像信号に対してデジタル－アナログ変換（Ｄ／Ａ変換）や増幅などの信号処理を施した後、インタフェース１６を介して表示部１７に送信することにより行われる。ここで表示部１７は、インタフェース１６を介して供給された画像信号に応じて画像を表示し、例えば画像処理装置１の筐体に設置された液晶表示装置より構成される。

【００３３】図４は、図３に示された画像処理装置を示す斜視図である。図４に示されるように、本実施の形態に係る画像処理装置１は電源スイッチ１０１と、シャッター１０２と、ファインダ１０３と、撮影モード設定部１９に撮影モードを設定するための撮影モード設定キー１０４と、表示部１７に映された画像を上方向へスクロールするための上方向スクロールキー２０１と、表示部１７に映された画像を下方向へスクロールするための下方向スクロールキー２０２と、決定キー２０３とを含む。

【００３４】以下において、上記のような構成を有する画像処理装置の動作を、図４と図５に示されたフローチャートとを参照しつつ説明する。まず最初に、電源スイッチ１０１を切り替えて画像処理装置１を起動し、撮影モードの選択を行う。ここで、上記撮影モードは通常のスナップ写真を撮影する通常モードと、撮影した画像のあおり歪みを補正した画像を生成するあおり補正モードよりなる。そして、この撮影モードの選択は、ユーザが撮影モード設定キー１０４を操作することによりなされる。なお撮影モード設定部１９として、画像処理装置１の本体には撮影モード設定キー１０４が設けられる。但し、撮影モード設定部１９は、本体とは別個に設けられるハードウェア又はソフトウェア等で構成しても良い。

【００３５】そして図５に示されるように、ステップＳ１においてあおり補正モードを選択するか否か判断され、あおり補正モードが選択されず通常モードが選択されると、ステップＳ１０へ進みユーザにより所望の被写体のスナップ写真が撮影される。

【００３６】一方、ステップＳ１においてあおり補正モードが選択されると、ステップＳ２へ進む。そして、ユーザは撮像部１１により被写体面ＰＬを少なくとも二枚撮影し、画像処理装置１には被写体像が取り込まれる。なお、このとき互いに被写体像の一部が重なり合うように各々の画像が撮影される必要がある。

【００３７】次に、ステップＳ３において被写体像の入力が終了したか否かが判断され、終了していない場合にはステップＳ２へ戻り、さらに被写体像の入力が継続される。一方、ユーザによる撮影終了の指示により被写体像の入力を終了した場合には、ステップＳ４へ進む。なお、上記指示は撮影モード設定キー１０４をもう一度押して通常モードに切り替えることによりなされる他、撮影終了を指示するためのスイッチを別途設けてもよい。

【００３８】また、撮影中においては図６に示されるように、表示部１７に例えば「１枚目」等のような現在の撮影枚数と、「撮影モード設定キーを押すと終了」等のような撮影終了方法とをオーバーレイ表示しても良い。

【００３９】そして、上記のように撮影が終了すると、ステップＳ４以下においてあおり歪みを補正する動作に入るが、まずステップＳ４においてどの画像のあおり歪みを補正するかを選択して該画像を設定する。なお、この時選択された画像は、以下において「基準画像」とも呼ぶ。そして、この基準画像の設定は基準画像設定部２０において行われる。以下において、基準画像設定部２０の構成及び動作を詳しく説明する。

【００４０】図７は、図３に示された基準画像設定部２０のレイアウトを示す図である。図７に示されるように、基準画像設定部２０は上方向スクロールキー２０１と、下方向スクロールキー２０２及び決定キー２０３を含む。そして、図７に示されるようにステップＳ３においてユーザにより撮影終了の指示がなされると、表示部１７において「基準画像設定」という文字がオーバレイ表示され、ユーザに基準画像を選択するよう指示される。

【００４１】するとユーザにより、上方向スクロールキー２０１や下方向スクロールキー２０２が操作され、上記ステップＳ２において撮影された画像が順次切り替えつつ表示される。なお、上方向スクロールキー２０１を押すことにより、現在表示されている画像の１つ前に撮影された画像が表示され、また下方向スクロールキー２

０２を押すことにより、現在表示されている画像の１つ後に撮影した画像が表示される。そして、基準画像として選択される画像が表示部１７に表示されている状態で決定キー２０３を押すと、その時点で表示されている画像が基準画像として決定される。

【００４２】そして上記基準画像としては、撮影された複数の画像の中で被写体面ＰＬが最も広い領域に渡り写っており、かつ、撮影時における撮像面の被写体面に対してなす角ができるだけ小さい画像が、ユーザにより選択される。

【００４３】ここで、被写体領域と上記傾斜角とを装置内部で計算し、該計算の結果に応じてあおり歪みを補正する対象、すなわち基準画像として最適な画像を自動的に選択するようにすることも考えられる。図８は、このような動作を実現する画像処理装置２の構成を示す図である。図８に示されるように、画像処理装置２には図３に示された画像処理装置１に含まれた基準画像設定部２０の代わりに被写体領域決定部２３が備えられる。

【００４４】そして、上記被写体領域決定部２３は、撮影した画像において被写体が占める領域を検出する処理を行い、例えば文献『画像の処理と認識』（安居院猛・長尾智晴共著、昭晃堂）に記載されているように、

（ａ）領域成長法や領域分割法のように画像上でクラスタリングを行う方法、（ｂ）ヒストグラムによる領域分割など、特徴空間上でクラスタリングを行う方法、

（ｃ）輪郭線追跡などの画像中のエッジを用いる方法、

（ｄ）テクスチャ解析、などの領域分割方法が適用される。但し、被写体面が矩形である場合には、画像上での被写体の四隅の頂点座標が外部入力されることにより、被写体の領域が一意に決定される。

【００４５】このように被写体領域決定部２３で得られた被写体の領域を示すデータは、画像歪み補正部２２へ供給され、該領域が最も広い画像が画像歪み補正部２２で選択される。さらに画像歪み補正部２２では、以下において詳述するように、撮像面の被写体面ＰＬに対してなす角度が計算されるため、上記領域が最も広い画像が複数ある場合、すなわち例えば被写体面の全体が写っている画像が複数ある場合には、上記角度が最も小さい画像が最終的に基準画像として選択される。

【００４６】なお、以上のような自動的に基準画像を選択する機能は、以下におけるいずれの実施の形態においても同様に適用できる。

＊【００４７】次にステップＳ５へ進み、上記のように決定された基準画像の中において特徴点が検出され、該基準画像の少なくとも一部において重複する画像（以下において、「参照画像」とも呼ぶ。）の中においては上記特徴点と同一箇所を示す対応点が検出される。このような特徴点と対応点の検出は、図３に示された対応検出部２１により行われる。そこで、以下においてこの対応検出部２１の構成及び動作を詳しく説明する。

【００４８】対応検出部２１は、上記のように互いに重複した領域を持つ２枚の画像において、撮影した同一の部分を検出するものである。そして、ここでは相関演算を用いた方法について説明する。

【００４９】図９は、図３に示された対応検出部２１の構成を示す図である。図９に示されるように、対応検出部２１はフレームメモリ１５に接続された特徴点設定部２１１と、特徴点設定部２１１及びフレームメモリ１５に接続された相関演算部２１２とを備える。なお、図３に示されたフレームメモリ１５には、基準画像と参照画像とが格納されている。

【００５０】ここで特徴点設定部２１１は、基準画像において特徴点の位置を決定したのち、その特徴点を中心とする（２Ｎ＋１）×（２Ｐ＋１）個の濃淡パターンを抽出し、相関窓と呼ばれる領域のデータを作成する。なお上記特徴点の位置は、角（corner）のように画像の濃度パターンが特徴的である箇所を抽出することにより決定される。

【００５１】また相関演算部２１２は、基準画像に基づいて作成した相関窓の濃淡パターンとほぼ一致する箇所を、参照画像内において相関演算を実行することにより検出し、これを対応点と決定する。ここで、相関演算によるブロックマッチングにより対応点を検出する一例について、図１０を参照しつつ説明する。

【００５２】図１０に示されるように、（２Ｎ＋１）×（２Ｐ＋１）個の濃淡パターンからなる相関窓２１５，２１６のブロックマッチングにおいて、基準画像７内の座標（x_{i0}，y_{i0}）を有するｉ番目の特徴点２１３と、参照画像９内の座標（$x_{i0}+dx_i$，$y_{i0}+dy_i$）を有する対応点２１７の相互相関値S_iは、次式により計算される。

【００５３】

【数１】

$$S_i=\frac{1}{K}\sum_{x=-N}^{N}\sum_{y=-P}^{P}\left[I_s(x_{i0}+x,y_{i0}+y)-\overline{I_s(x_{i0},y_{i0})}\right]\times\left[I_r(x_{i0}+dx_i+x,y_{i0}+dy_i+y)-\overline{I_r(x_{i0}+dx_i,y_{i0}+dy_i)}\right] \quad (1)$$

なお、上記式（１）においてI_s（ｘ，ｙ）は基準画像７の座標点（ｘ，ｙ）における濃度を示し、I_r（ｘ，ｙ）は参照画像９の座標点（ｘ，ｙ）における濃度を示す。また、$\overline{I_s}$（ｘ，ｙ）は基準画像７における相関窓２１５内の座標点（ｘ，ｙ）を中心とした（２Ｎ＋１）×（２Ｐ＋１）個のパターンにおける平均

濃度を示し、／Ｉ，（ｘ，ｙ）は参照画像９における相関窓２１６内の座標点（ｘ，ｙ）を中心とした（２Ｎ＋１）×（２Ｐ＋１）個のパターンにおける平均濃度を示す。また、Ｋは定数を示す。

【００５４】そして、上記式（１）により各特徴点２１３に対して、相互相関値Ｓ，の最大値が予め定められた閾値以上である点を求めることにより、参照画像９における対応点２１７が求められる。なお、相互相関値Ｓ，の最大値が閾値以下ならば、対応点は存在しないものとされる。

【００５５】このようにして、特徴点と対応点の検出が終了すると、図５に示されたステップＳ６において基準画像７のあおり歪みを補正するパラメータを計算すると共に、ステップＳ７において該パラメータを基に画像のあおり歪みを補正した画像を作成し動作を終了する。なお以下においては、それぞれ上記パラメータを「歪み補正パラメータ」、あおり歪みを補正した画像を「歪み補正画像」ともいう。

【００５６】そして、上記歪み補正パラメータの計算及び歪み補正画像の生成は、画像歪み補正部２２により実行される。以下において、この画像歪み補正部２２の構成及び動作について詳しく説明する。

【００５７】画像歪み補正部２２は、対応検出部２１が検出した特徴点と対応点の関係を用いて、被写体面を正面から撮影した画像に変換することにより、あおり歪みを補正する。そして、この画像歪み補正部２２の構成は図１１に示される。図１１に示されるように、画像歪み補正部２２は３次元演算部２２１とパラメータ算出部２２２及び座標変換部２２３を含む。ここで、３次元演算部２２１は対応検出部２１と基準画像設定部２０に接続され、パラメータ算出部２２２は３次元演算部２２１に接続される。また、座標変換部２２３はパラメータ算出部２２２とフレームメモリ１５及び基準画像設定部２０に接続される。

【００５８】以下において、画像歪み補正部２２の動作を説明する。なお以下においては、図１２に示されるように、被写体面ＰＬに対して基準画像７及び参照画像９が撮影されると共に、撮像部１１の光学系は図１３に示されるように、ｘ軸に関しては画像面２２４の右向きを正、ｙ軸に関しては画像面２２４の下向きを正、光軸方向のｚ軸に関しては撮像部１１の光学中心である原点Ｏから画像面２２４へ向かう向きを正、該光学系の焦点距離はｆとされる中心射影モデル（perspectiveprojectio＊n model）とされる場合を例として説明する。

【００５９】図１１に示された３次元演算部２２１は、上記特徴点２１３と対応点２１７との関係により、以下の３次元パラメータを算出する。すなわち、図１２に示される基準画像撮影時を基にした参照画像撮影時における撮像部１１の向きの変化を示す回転行列Ｒと、基準画像撮影時を基にした参照画像撮影時における撮像部１１の位置の変化を示す並進運動ベクトルｔと、被写体面ＰＬの向きを示す法線ベクトルｎとが算出される。そして、これら３つの３次元パラメータ{Ｒ，ｔ，ｎ}を求める方法は、主に以下の二つとされる。

【００６０】すなわち第一の方法として、８つ以上の特徴点と対応点の組により、各画像撮影時のカメラの位置や姿勢、及び各対応点の３次元座標を計算した上で、被写体が平面であると仮定して、該得られた３次元座標を１つの平面に当てはめる方法がある。

【００６１】また第二の方法として、４つ以上の特徴点と対応点の組より、射影変換行列（homography matrix）を計算し、得られた射影変換行列により各画像撮影時のカメラの位置や姿勢、及び被写体面の向きを算出する方法がある。

【００６２】ここで、上記第一の方法は、汎用の運動立体視技術であり、線形演算により上記パラメータ{Ｒ，ｔ，ｎ}が一意に求められるが、その詳細は３次元計測やコンピュータビジョンに関する一般的な文献（例えば『３次元ビジョン』徐剛・辻三郎共著、共立出版）に記録されている。一方、上記第二の方法は、被写体が平面であるという拘束条件のもとで成立する座標変換式（射影変換行列）を求めてから、カメラの向きと被写体面の向きを算出するものである。そして、３次元演算部２２１は、いうまでもなく上記第一及び第二のいずれの方法も採ることができるが、ここでは第二の方法に基づいた動作を説明する。

【００６３】まず射影変換行列の算出手順を詳しく説明する。ここで、基準画像から参照画像への射影変換とは、図１４に示されるように、基準画像７に写った被写体像が参照画像９と同じ方向から撮影された場合に得られる像に変換された画像１０を得ることを指す。そして、この射影変換を数式で表すと、基準画像における点（x_s，y_s）と参照画像における点（x_r，y_r）とが対応関係にある場合には、次式のようになる。

【００６４】

【数２】

$$\begin{cases} x_r = \dfrac{b_1 x_s + b_2 y_s + b_3}{b_7 x_s + b_8 y_s + 1} \\ y_r = \dfrac{b_4 x_s + b_5 y_s + b_6}{b_7 x_s + b_8 y_s + 1} \end{cases} \quad (2)$$

そして、上記の式（２）における８つの未知数b_1～b_8を

15 16

【００６５】

$$B=\begin{bmatrix} b_1 & b_2 & b_3 \\ b_4 & b_5 & b_6 \\ b_7 & b_8 & 1 \end{bmatrix} \quad (3)$$

と行列Ｂとしてまとめ、これを射影変換行列と呼ぶ。この射影変換行列Ｂを求めるには、基準画像における座標が（x_{si}，y_{si}）である特徴点と、参照画像における座標が（x_{ri}，y_{ri}）である対応点（ｉ＝１，…，Ｎ；Ｎ≧４）との組を４組以上用いる。ここで、座標（x_{si}，y_{si}）と座標（x_{ri}，y_{ri}）を上記※

【００６６】

【数４】

$$\sum_{i=1}^{N}\left[\left(\frac{b_1x_{si}+b_2y_{si}+b_3}{b_7x_{si}+b_8y_{si}+1}-x_{ri}\right)^2+\left(\frac{b_4x_{si}+b_5y_{si}+b_6}{b_7x_{si}+b_8y_{si}+1}-y_{ri}\right)^2\right]\rightarrow \min. \quad (4)$$

そして、上記式（４）は以下のように変形される。

【００６７】

★【数５】

★

$$\sum_{i=1}^{N}\left[\{b_1x_{si}+b_2y_{si}+b_3-(b_7x_{si}+b_8y_{si}+1)x_{ri}\}^2\right.$$
$$\left.+\{b_4x_{si}+b_5y_{si}+b_6-(b_7x_{si}+b_8y_{si}+1)y_{ri}\}^2\right]\rightarrow \min. \quad (5)$$

上記式（５）の左辺をb_1～b_8でそれぞれ変微分して得られた導関数の値が０になるという拘束条件を利用すると、b_1～b_8は連立一次方程式を解くことにより計算される。すなわち、射影変換行列Ｂは上記対応付けられた組を用いて、簡単な線形演算により求めることができる。

☆【００６８】続いて、射影変換行列Ｂより３次元パラメータ{Ｒ，ｔ，ｎ}を求める手順を説明する。被写体面の法線ベクトルｎを

【００６９】

【数６】

☆

$$n=\begin{bmatrix} a \\ b \\ c \end{bmatrix} \qquad \left(a^2+b^2+c^2=1,\ c>0\right) \quad (6)$$

とし、基準画像撮影時を基準とした被写体面の方程式を、

◆【００７０】

◆【数７】

$$(n,r)+d=0 \quad (7)$$

ここで、｜ｄ｜は原点から被写体面ＰＬまでの距離を示し、$r=[x\ \ y\ \ z]^T$とおかれる。また焦点距離ｆを用いて、式（２）は次式のように書き直される。

＊【００７１】

【数８】

＊

$$\begin{cases} x_r=f\dfrac{H_{11}x_s+H_{21}y_s+H_{31}f}{H_{13}x_s+H_{23}y_s+H_{33}f} \\ y_r=f\dfrac{H_{12}x_s+H_{22}y_s+H_{32}f}{H_{13}x_s+H_{23}y_s+H_{33}f} \end{cases} \quad (8)$$

さらに式（８）は

【００７２】

【数９】

※式（２）へ代入してb_1～b_8の解を求めればよいが、実際には画像に重畳するノイズ等の誤差により式（２）は成立しないので、以下に示す最小自乗演算を用いて解くことになる。

$$\begin{bmatrix} x_r \\ y_r \\ f \end{bmatrix} = s \begin{bmatrix} H_{11} & H_{21} & H_{31} \\ H_{12} & H_{22} & H_{32} \\ H_{13} & H_{23} & H_{33} \end{bmatrix} \begin{bmatrix} x_s \\ y_s \\ f \end{bmatrix} = s H^T \begin{bmatrix} x_s \\ y_s \\ f \end{bmatrix} \quad (9)$$

と変形される。但し、

【００７３】

$$s = \frac{1}{H_{13}x_s + H_{23}y_s + H_{33}f} \quad (10)$$

である。この時、式（９）の行列Ｈとパラメータ{Ｒ，ｔ，ｎ，ｄ}との関係は、次式のようになる。

$$H^T = s' R^T \left(dI + t n^T \right) \quad (11)$$

但し、ｓ’は定数であり、行列Ｈの各要素はスケール倍の自由度を有している。また、式（３）の射影変換行列Ｂから式（９）の行列Ｈへの変換は、次式により行うこ★とができる。

【００７５】

【数１２】

$$H^T = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & f \end{bmatrix} B \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1/f \end{bmatrix} = \begin{bmatrix} b_1 & b_2 & b_3/f \\ b_4 & b_5 & b_6/f \\ f b_7 & f b_8 & 1 \end{bmatrix} \quad (12)$$

以下において、行列Ｈより未知のパラメータ{Ｒ，ｔ，ｎ，ｄ}を求める手順を示す。但し、被写体面との距離を表す変数ｄと並進運動ベクトルｔの大きさのスケールは不定であるので、

【００７６】

【数１３】

$$\|t\| = 1 \quad (13)$$

と仮定する。ここで、パラメータ{Ｒ，ｔ，ｎ，ｄ}の解を導出する計算過程は、文献『画像理解－３次元認識の数理－』（金谷健一著、森北出版）に詳細が記されているが、その結果をまとめると以下のようになる。

（ｉ）式（９）の行列Ｈの各要素に適当な定数をかけて、ｄｅｔ［Ｈ］＝１となるようにする。（ｉｉ）対称行列HH^Tの固有値をσ_1^2，σ_2^2，σ_3^2とし、対応☆する固有ベクトルu_1，u_2，u_3を互いに直交し、この順に右手系を作る単位ベクトルにとる。但し$\sigma_1 \geqq \sigma_2 \geqq \sigma_3 > 0$とする。（ｉｉｉ）$\sigma_1 = \sigma_2 = \sigma_3$ならば、運動パラメータは、

【００７７】

【数１４】

$$t = 0,\ R = H \quad (14)$$

であり、被写体面のパラメータ{ｎ，ｄ}は不定である。そうでなければ、次のように２組の解が得られる。

（ｉｖ）被写体面のパラメータ{ｎ，ｄ}は、次のように定まる。

【００７８】

【数１５】

$$n = \frac{\varepsilon}{\sqrt{\sigma_1^2 - \sigma_3^2}} \left(\pm \sqrt{\sigma_1^2 - \sigma_2^2} u_1 + \sqrt{\sigma_2^2 - \sigma_3^2} u_3 \right) \quad (15)$$

【００７９】

◆◆【数１６】

$$d = -\frac{\sigma_2}{\sigma_1 - \sigma_3} \quad (16)$$

但しε＝±１であり、εをｃ＞０になるように選ぶ。また、（ｖ）単位並進運動ベクトルｔは次のように定まる。

＊【００８０】

【数１７】

$$t = \frac{1}{\sigma_2 \sqrt{\sigma_1^2 - \sigma_3^2}} \left(\pm \sigma_3 \sqrt{\sigma_1^2 - \sigma_2^2} u_1 - \sigma_1 \sqrt{\sigma_2^2 - \sigma_3^2} u_3 \right) \quad (\text{複号同順}) \quad (17)$$

また、回転行列Ｒは次のように定まる。

【００８１】

$$R=\frac{1}{\sigma_2}\left[I-\frac{1}{(n,\ t)+d}nt^T\right]H \tag{18}$$

従って、行列Ｂよりパラメータ{Ｒ，ｔ，ｎ，ｄ}の解が２通り得られるが、大抵の場合は導出された値より真の解を判別することができる。なお、途中の計算で撮像部１１の焦点距離ｆを使用するが、焦点距離ｆの値は撮像部１１の光学系パラメータを内部メモリ（図示せず）に記憶するなどの方法により容易に得ることが可能である。また、撮像部１１の光学系の焦点距離が可変で基準画像と参照画像の焦点距離が異なる場合でも、双方の画像の焦点距離が既知であれば、上記３次元パラメータ算出手順をそのまま適用でき、焦点距離は光学系にエンコーダを設置するなどの方法により検出可能である。

【００８２】次に、図１１に示されたパラメータ算出部２２２は、被写体面を撮影した時の撮像部１１と３次元演算部２２１で算出された被写体面の向きとの関係に基づき、あおり歪みを補正するパラメータを計算する。こ※こで、本実施の形態においては図１５に示されるように、３次元演算部２２１が算出した被写体面に平行な平面を被投影面３１として、あおり歪みを有する被写体像を含む画像面３０を投影するという射影変換を行うことにより、画像のあおり歪みが補正される。ここで例えば、画像面３０上の点Ｐ１は被投影面３１上の点Ｐ２に投影される。以下において上記あおり歪みを補正するパラメータの計算方法を説明する。

【００８３】まず、図１６に示されるように、装置座標系３３におけるｚ軸を被投影面３１の単位法線ベクトルに一致させる座標変換を示す回転行列Ｒ’を求める。この場合、次の関係式が成立する。

【００８４】

$$R'\begin{bmatrix}0\\0\\1\end{bmatrix}=\begin{bmatrix}a\\b\\c\end{bmatrix} \tag{19}$$

そして、上記式（９）を満たす回転行列Ｒ’は多数存在するが、ここでは回転行列Ｒ’を次式のように定義する。

【００８５】

$$R'=R'_yR'_x=\begin{bmatrix}R'_{11}&R'_{12}&R'_{13}\\R'_{21}&R'_{22}&R'_{23}\\R'_{31}&R'_{32}&R'_{33}\end{bmatrix} \tag{20}$$

但し、ここでＲ’ｘとＲ’ｙはそれぞれ次のように示される。

【００８６】

$$R'_x=\begin{bmatrix}1&0&0\\0&\cos\alpha&-\sin\alpha\\0&\sin\alpha&\cos\alpha\end{bmatrix},\qquad R'_y=\begin{bmatrix}\cos\beta&0&\sin\beta\\0&1&0\\-\sin\beta&0&\cos\beta\end{bmatrix} \tag{21}$$

これは、図１７に示されるように、以下の順序で装置座標系（ｘｙｚ座標系）３３を回転させて、ｘ’ｙ’ｚ’座標系に変換することに相当する。（ｉ）装置座標系３３をｙ軸の回りにだけβ回転させる。そして、この回転により得られる座標系をｘ１，ｙ１，ｚ１座標系とする。

◆（ｉｉ）装置座標系をｘ１軸の回りにαだけ回転する。

【００８７】ここで、式（１９）と式（２０）を用いると、回転角は次式のように導出される。

【００８８】

$$\alpha=\sin^{-1}(-b) \tag{22}$$

$$\beta=\sin^{-1}\left(\frac{a}{\sqrt{a^2+c^2}}\right) \tag{23}$$

そして、このように求められた回転角を式（２０）及び式（２１）に代入することにより、行列R'を一意に定めることができる。

【００８９】次に、画像面３０上の座標を被投影面３１上に座標変換する。すなわち、図１５において、画像面３０の点Ｐ１に対応する３次元ベクトルｐを延長したと＊きに被投影面３１と交差する点Ｐ２を、座標変換後の座標とする。そして、装置座標系３３を基準とした点Ｐ１に対応する３次元ベクトルｐは、次式で示される。

【００９０】

【数２３】

$$P=\frac{k}{ax_s+by_s+cf}\begin{bmatrix}x_s\\y_s\\f\end{bmatrix}\qquad(k>0)\tag{24}$$

ここで、ｋは撮像部１１の光学中心ｏから被投影面までの距離を表す拡大係数であるため、ｋは作成される歪み補正画像の大きさを表している。また３次元ベクトルｐは、基準画像撮影時の装置座標系３３を基準にして点Ｐ１を表したベクトルであるが、これを回転行列R'を用※いて次式のように座標変換することにより、撮像部１１を被写体面と正対させた時の３次元ベクトルｐ'に変換される。

【００９１】

【数２４】

$$P'=\begin{bmatrix}X\\Y\\Z\end{bmatrix}=R'^{-1}P=\frac{k}{ax_s+by_s+cf}\begin{bmatrix}R'_{11}&R'_{21}&R'_{31}\\R'_{12}&R'_{22}&R'_{32}\\R'_{13}&R'_{23}&R'_{33}\end{bmatrix}\begin{bmatrix}x_s\\y_s\\f\end{bmatrix}\tag{25}$$

従って、式（２５）のｘ座標とｙ座標を座標変換後に得られる座標とすることにより、あおり歪みを補正した画像が得られる。そして、以上のような手順により、式（２５）を用いて基準画像のあおり歪みを補正するパラメータを算出することができる。

【００９２】次に、座標変換部２２３はパラメータ算出部２２２により算出されたあおり歪み補正パラメータを基に、基準画像を座標変換して歪み補正画像を作成する。具体的には、座標変換後の座標（Ｘ，Ｙ）に対応する変換前の座標（x_s，y_s）を式（２５）に基づいて計算し、計算された座標（x_s，y_s）の近傍における画素値を基に座標（Ｘ，Ｙ）における画素値を補間演算により決定する。なお、この補間演算は双一次補間法やＢースプライン補間法などの既存の方法を用いて行えばよい。

【００９３】以上のように、本発明の実施の形態１に係る画像処理装置によれば、互いに少なくとも一部が重なり合うように被写体面が２枚以上撮影されたときには、その撮影された任意の画像におけるあおり歪みを補正してより適正な被写体の全体像を得ることができる。

【００９４】すなわち、上記手順においては全ての画像において被写体の全範囲を撮影する必要はなく、例えば図１４に示されるように、被写体の全体を撮影した画像と、被写体の一部分のみを撮影した画像があれば足りる。そしてこのような場合、基準画像設定部２０により被写体の全体を撮影した画像の方を基準画像として選ぶことができるので、あおり歪みが補正された被写体の全体像を生成することができる。

【００９５】また歪み補正画像を上記の方法により生成するためには、最低限二枚の被写体像があればよいので、撮影する枚数を二枚に限定すれば、ユーザにとって画像の入力や撮影及び基準画像の設定が簡略化されるだけではなく、画像を記憶するために必要なメモリ容量や特徴点及び対応点の検出、射影変換行列の計算に要する計算コストを小さくすることができる。

［実施の形態２］図１８は、本発明の実施の形態２に係る画像処理方法及び画像処理装置を説明するための図である。図１８（ａ）に示されるように、同一の被写体面ＰＬの静止画像が、画像の一部においてそれぞれ重複するように複数の方向d_1～d_kから撮影された場合における、本実施の形態に係る画像処理装置６の動作について説明する。

【００９６】ここで、図１８（ａ）に示されるように、方向D_mから撮影することにより画像ｉｍｎ（ｎ＝１，２…，ｊ，…，ｋ）が得られ、例えば画像ｉｍ１と画像ｉｍ２のように隣り合う方向において撮影することにより得られた画像ｉｍｊと画像ｉｍ（ｊ＋１）（$1\leqq j\leqq k-1$）との間ではそれぞれ重複領域があるとする。

【００９７】そして、本実施の形態２に係る画像処理装置においては、図１８（ｂ）に示されるように、基準画像として選択されたいずれか一つの画像ｉｍｊに整合するように他の画像が貼り合わされ、合成画像ＩＭＣが得られる。

【００９８】図１９は、本実施の形態２に係る画像処理装置６の構成を示す図である。図１９に示されるように、画像処理装置６は、図３に示された上記実施の形態１に係る画像処理装置１と同様な構成を有するが、画像歪み補正部２２の代わりに画像合成部２４が備えられる

点で相違するものである。ここで、画像合成部２４は対応検出部２１で得られた特徴点と対応点の関係を基に座標変換することにより、互いに重複する領域を持つ画像を貼り合わせるが、この動作については後に詳しく説明する。

【００９９】図２０は、図１９に示された本実施の形態２に係る画像処理装置６の動作を示すフローチャートである。まず最初に、電源スイッチ１０１を切り替えて画像処理装置１を起動し、撮影モードの選択を行う。ここで、上記撮影モードは通常のスナップ写真を撮影する通常モードと、撮影した画像のあおり歪みを補正した画像を生成するあおり補正モードよりなる。そして、この撮影モードの選択は、ユーザが撮影モード設定キー１０４を操作することによりなされる。なお撮影モード設定部１９として、画像処理装置１の本体には撮影モード設定キー１０４が設けられる。但し、撮影モード設定部１９は、本体とは別個に設けられるハードウェア又はソフトウェア等で構成しても良い。

【０１００】そして図５に示されるように、ステップＳ１においてあおり補正モードを選択するか否か判断され、あおり補正モードが選択されず通常モードが選択されると、ステップＳ１０へ進みユーザにより所望の被写体のスナップ写真が撮影される。

【０１０１】一方、ステップＳ１においてあおり補正モードが選択されると、ステップＳ２へ進む。そして、ユーザは撮像部１１により被写体面ＰＬを少なくとも二枚撮影し、画像処理装置６には被写体像が取り込まれる。なお、このとき互いに被写体像の一部が重なり合うように各々の画像が撮影される必要がある。

【０１０２】次に、ステップＳ３において被写体像の入力が終了したか否かが判断され、終了していない場合にはステップＳ２へ戻り、さらに被写体像の入力が継続される。一方、ユーザによる撮影終了の指示により被写体像の入力を終了した場合には、ステップＳ４へ進む。なお、上記指示は撮影モード設定キー１０４をもう一度押して通常モードに切り替えることによりなされる他、撮影終了を指示するためのスイッチを別途設けてもよい。

【０１０３】そして、上記のように被写体の撮影が終了すると、ステップＳ４以下において、複数枚の画像を貼り合せた合成画像を生成する動作に入る。まずステップＳ４において、どの画像を基準に合成画像を生成するかを選択する。なお、このとき選択された画像が上記基準画像であり、以下においては例として図１８に示される画像ｉｍｊが基準画像として選択された場合について説明する。また、この基準画像の設定は基準画像設定部２０においてなされるが、基準画像設定部２０の構成及び動作は上記実施の形態１における場合と同様である。

【０１０４】次に、ステップＳ５において、図１８（ａ）に示された隣接する方向から撮影された画像対、すなわち画像ｎと画像（ｎ＋１）（$1 \leqq n \leqq k-1$）との間において特徴点と、該特徴点と同一の箇所を示す対応点を検出する。この特徴点と対応点の検出は、対応検出部２１により行われる。ここで、対応検出部２１の構成及び動作は上記実施の形態１における場合と同様である。

【０１０５】そして、特徴点と対応点の検出が終了すると、得られた両点の関係を基に、基準画像に整合するよう座標変換した上で画像が貼り合わされる。ここで、座標変換として射影変換を用いるとき、ステップＳ６において射影変換行列を計算すると共に、ステップＳ７において上記貼り合わせにより合成画像が生成される。このような射影変換行列の算出及び合成画像の生成は、画像合成部２４により実行される。以下において、この画像合成部２４の構成及び動作について詳しく説明する。

【０１０６】図２１は、図１９に示された画像合成部２４の構成を示す図である。図２１に示されるように、画像合成部２４は射影変換算出部２３１と座標変換部２３２とを含む。ここで、射影変換算出部２３１は基準画像設定部２０と対応検出部２１とに接続され、座標変換部２３２は基準画像設定部２０とフレームメモリ１５及び射影変換算出部２３１に接続される。

【０１０７】そして、射影変換算出部２３１は４つ以上の特徴点と対応点の組を用いて、式（３）で示した射影変換行列Ｂを算出する。その算出手順は上記実施の形態１における場合と同様であり、式（５）の最小自乗計算を行えばよい。ここで、本実施の形態においては、（ｋ－１）個の画像対間における射影変換行列を計算し、さらに各々の画像から基準画像への射影変換行列を求める必要がある。

【０１０８】より具体的には、図１８に示されるように画像ｉｍｎ（ｎ＝１～ｋ－１）から画像ｉｍ（ｎ＋１）への射影変換行列をB_n、また画像ｉｍｎから画像ｉｍｊへの射影変換行列を

【０１０９】

【数２５】

$$B_{n \to j}$$

とおくと、この射影変換行列は次式に基づいて計算できる。

【０１１０】

【数２６】

$$B_{n\to j}=\begin{cases}\prod_{l=n}^{j-1}B_l & (n<j)\\ \left(\prod_{l=j}^{n-1}B_l\right)^{-1} & (n>j)\end{cases} \qquad (26)$$

ここで、座標変換部２３２は、射影変換算出部２３１により算出された式（２６）により示される射影変換行列を基に、画像ｎを基準とされる画像ｉｍｊに貼り合わされる。具体的には、まず基準画像における座標変換後の＊座標（Ｘ，Ｙ）に対応する、画像ｎにおける座標変換前の座標（ｘ，ｙ）を次式に基づき計算する。

【０１１１】

【数２７】

$$\begin{bmatrix}x\\ y\\ 1\end{bmatrix}=s\,B_{n\to j}^{-1}\begin{bmatrix}X\\ Y\\ 1\end{bmatrix} \qquad (27)$$

但しｓは、式（２７）における左辺の列ベクトルの第三成分を１とするための定数である。次に、座標変換前の座標（ｘ，ｙ）近傍における画素値を基に、座標（Ｘ，Ｙ）の画素値を補間演算により決定する。そして、この補間演算は双一次補間法やＢ－スプライン補間法などの既存の方法を用いて行えばよい。

【０１１２】以上のように、本実施の形態に係る画像処理装置６によれば、互いに一部が重なり合うように被写体面ＰＬを２枚以上撮影し、選択した基準画像に対して他の画像を貼り合わせることにより、被写体面ＰＬの広い領域に渡る合成画像が生成される。この場合基準画像設定部２０により、被写体に対してほぼ正対する方向から撮影された画像、すなわちあおり歪みの小さい画像を基準画像として選ぶことができるため、結果的にあおり歪みの小さい全体的な被写体像を、上記合成画像として得ることができる。

〔実施の形態３〕上記実施の形態１及び２に係る画像処理装置においては、先に被写体像が２枚以上入力又は撮影された後に、歪み補正の対象とされ又は合成画像の基準とされる基準画像が選択される。これに対し、本実施の形態３に係る画像処理装置は、被写体を撮影する前に予め上記基準画像が設定される。

【０１１３】図２２は、本発明の実施の形態３に係る画像処理装置８の構成を示す図である。図２２に示されるように、本実施の形態に係る画像処理装置８は、図３に示された実施の形態１に係る画像処理装置１と同様な構成を有するが、通知部２６をさらに備える点で相違するものである。ここで、通知部２６は主制御部１４と基準画像設定部２０に接続される。

【０１１４】なお、該画像処理装置８に含まれたシャッター１１３及びインタフェース１６は主制御部１４に接続され、ファインダ２４１はインタフェース１６に接続される。

【０１１５】次に、本発明の実施の形態３に係る画像処理装置８の動作を、図２３のフローチャートを参照しつつ説明する。まず、ステップＳ１においてあおり補正モードを選択するか否か判断され、あおり補正モードが選択されず通常モードが選択されると、ステップＳ１０へ進みユーザにより所望の被写体のスナップ写真が撮影される。

【０１１６】一方、ステップＳ１においてあおり補正モードが選択されると、ステップＳ２へ進む。そしてステップＳ２においては、あおり歪みの補正対象とする画像、すなわち基準画像が基準画像設定部２０に設定される。ここで基準画像設定部２０は、図２４に示されるように、カーソルキー２０４と決定キー２０３とを含む。そして、表示部１７には「基準画像設定」という文字がオーバレイ表示されると共に、ユーザにこれから撮影する枚数と、該撮影において何枚目に撮る画像を基準画像とするのかを指定する基準画像指定値とを設定するよう指示される。ここで、例えばユーザはカーソルキー２０４の上又は下方向スクロールキーを操作することにより撮影枚数と基準画像の設定間を切り替え、かつ左又は右方向スクロールキーを操作することにより枠内の設定値を増減させることによって、所望の撮影枚数と基準画像指定値とを設定することができる。なお、決定キー２０３が押されることにより上記基準画像の設定が完了される。

【０１１７】次に、ステップＳ３においてユーザは少なくとも２枚以上の被写体像の撮影を開始する。なおこのとき、互いに一部が重なり合うように各画像が撮影される必要がある。そして、画像を撮影する度にシャッター１１３から主制御部１４へ撮影信号が供給されることによって、主制御部１４に内蔵されたカウンタがインクリメントされ、該カウンタから次の撮影が何枚目であるかを示す枚数特定信号が通知部２６へ供給される。ここで、基準画像設定部２０より上記基準画像指定値を示す信号が通知部２６に内蔵されたレジスタに供給され、該レジスタに基準画像指定値が格納されているため、ステップＳ４において通知部２６は常に該レジスタに格納さ

れた上記基準画像指定値と上記枚数特定信号が示す値とを比較し、今度撮影する画像が基準画像とされるものであるか否かを判断する。

【０１１８】そして、上記比較において両者の値が一致し、これから撮影しようとする画像が基準画像とされるものである場合には、ステップＳ５へ進み、通知部２６はユーザに基準画像の撮影であることを通知する。すなわち、このとき通知部２６からは主制御部１４を介してインタフェース１６へ通知信号が供給され、図２５に示されるように、該通知信号に応じてインタフェース１６によりファインダ２４１内の被写体像３５横のインジケータ２４２が点灯される。従って、撮影時にユーザにより容易に基準画像の撮影であるか否かが認識される。なお上記における通知は、表示部１７へ所定のテキストやシンボルを表示すること等によって行っても良い。

【０１１９】次にステップＳ６へ進むが、ステップＳ４において次に撮影する画像が基準画像とされないと判断された場合には、直接ステップＳ６へ進む。そして、このステップＳ６においては、被写体の撮影（被写体画像の入力）が終了したか否かが判断され、終了しないと判断された場合にはステップＳ３へ戻る。一方、終了すると判断された場合にはステップＳ７へ進む。ここで、撮影の終了はユーザの指示に応じて判断され、該指示は撮影モード設定部１９における設定が通常モードに切り替えられ、又は撮影終了のために設けられたスイッチが押されること等によりなされるものとすることができる。

【０１２０】次に、ステップＳ７では基準画像の中において特徴点が検出され、該基準画像の少なくとも一部において重複する画像の中においては上記特徴点と同一箇所を示す対応点が検出される。このような特徴点と対応点の検出は、図２２に示された対応検出部２１により行われる。なお、該対応検出部２１の構成及び動作は、上記実施の形態１の場合と同様である。

【０１２１】そして、ステップＳ８において基準画像のあおり歪みを補正するためのパラメータを算出すると共に、ステップＳ９において上記パラメータを基にあおり歪みを補正した画像を生成して動作を終了する。なお、該パラメータの算出及びあおり歪みを補正した画像の生成は画像歪み補正部２２により行われるが、この画像歪み補正部２２の構成及び動作は上記実施の形態１の場合と同様である。

【０１２２】以上のように、本実施の形態３に係る画像処理装置８によれば、撮影前に基準画像指定値を設定することにより、ユーザによる画像撮影において、次に撮影する画像が基準画像とされるものであるか否かが通知部２６によってユーザに通知されるため、ユーザは基準画像の撮影を容易に認識することができる。そしてユーザは、基準画像の撮影時には被写体の所望の領域が撮影範囲に入るよう特に注意を払うことができる。またさらに、基準画像の撮影ミスを減少させることができる。

【０１２３】なお、通知部２６により基準画像指定値の設定に応じてユーザへ基準画像の撮影を通知する技術は、上記実施の形態２に係る画像処理装置６にも適用可能であることはいうまでもない。

［実施の形態４］上記実施の形態に係る画像処理装置は、撮像部に含まれた単一の光学系を移動させることにより、被写体を異なる方向から少なくとも２度撮影する必要があったが、本実施の形態に係る画像処理装置では撮像部４１に２以上の光学系が並設され、一度の撮影で異なる方向から撮影された被写体像が複数枚得られるようにされる。

【０１２４】図２６は、本発明の実施の形態４に係る画像処理装置４０の構成を示す図である。図２６に示されるように、本実施の形態４に係る画像処理装置４０は、図３に示された実施の形態１に係る画像処理装置１と同様な構成を有するが、撮像部４１には２つの光学系１１Ａ，１１Ｂを含む点で相違するものである。

【０１２５】以下において、本実施の形態に係る画像処理装置の動作を図２７のフローチャートを参照しつつ説明する。まず最初に、画像処理装置４０を起動し、撮影モードの選択を行う。ここで、上記撮影モードは通常のスナップ写真を撮影する通常モードと、撮影した画像のあおり歪みを補正した画像を生成するあおり補正モードよりなる。そして、この撮影モードの選択は、ユーザが撮影モード設定キーを操作することによりなされる。なお撮影モード設定部１９として、画像処理装置４０の本体には撮影モード設定キー１０４が設けられる。但し、撮影モード設定部１９は、本体とは別個に設けられるハードウェア又はソフトウェア等で構成しても良い。

【０１２６】そして図２７に示されるように、ステップＳ１においてあおり補正モードを選択するか否か判断され、あおり補正モードが選択されず通常モードが選択されると、ステップＳ１０へ進みユーザにより所望の被写体のスナップ写真が撮影される。

【０１２７】一方、ステップＳ１においてあおり補正モードが選択されるとステップＳ２へ進み、基準画像設定部２０に対してあおり歪みを補正する対象としての基準画像が設定される。ここで基準画像設定部２０には、図２８に示されるように、上方向スクロールキー２０１及び下方向スクロールキー２０２と決定キー２０３とが含まれる。また、表示部１７には「基準画像設定」という文字がオーバレイ表示されると共に、いずれの光学系１１Ａ、１１Ｂで撮影された画像を上記基準画像とするかという選択がユーザに求められる。

【０１２８】すると、ユーザは上方向スクロールキー２０１又は下方向スクロールキー２０２を操作することにより、例えば三角形で示されるポインタを表示部１７上で動かし、光学系１１Ａを選択する「カメラ１」という表示、あるいは光学系１１Ｂを選択する「カメラ２」という表示のいずれかを指定する。そして、上記ポインタ

がいずれかの光学系を指定した状態で決定キー２０３を押すと、該指定した光学系により撮影された画像が上記基準画像とされる。ここで、上記基準画像の設定情報は基準画像設定部２０から主制御部１４へ供給される。

【０１２９】次に、ステップＳ３においてユーザは被写体の撮影を行う。このとき表示部１７には、主制御部１４による制御により、ステップＳ２で選択された光学系で撮影された画像のみを表示することとすれば、あおり歪みを補正しようとする画像が被写体の所望の範囲を含んでいるか否かがユーザにより容易に確認される。

【０１３０】そしてステップＳ４においては、基準画像内で特徴点が検出されると共に、基準画像と重複した領域を有する画像内で該特徴点と同一の箇所を示す対応点が検出される。なお、この特徴点及び対応点の検出は、対応検出部２１により実行されるが、この対応検出部２１の構成及び動作は上記実施の形態１の場合と同様である。

【０１３１】次に、ステップＳ５において基準画像のあおり歪みを補正するためのパラメータを算出すると共に、ステップＳ６において該パラメータを基にあおり歪みを補正した画像を生成し、動作を終了する。ここで、上記パラメータの算出及びあおり歪みを補正した画像の生成は画像歪み補正部２２により実行されるが、この画像歪み補正部２２の構成及び動作は上記実施の形態１の場合と同様である。

【０１３２】以上のように、本実施の形態４に係る画像処理装置４０によれば、撮像部４１は光学系を少なくとも２つ備えるため、ユーザは１回の撮影動作により上記実施の形態に係る画像処理装置により得られる補正画像を得ることができる。また、選択した光学系において撮影された画像のみを表示部１７に表示するようにすれば、あおり歪みを補正しようとする画像が被写体の所望の範囲を含んでいるか否かがユーザにより容易に確認できるので、ユーザは基準画像の撮影に一層注意を払うことができ、撮影ミスの可能性を減少させることができる。

【０１３３】また、図２６に示された撮像部４１には光学系が３つ以上含まれてもよく、このような複数の光学系を含む撮像部は、上記実施の形態２に係る画像処理装置６に備えられてもよいことはいうまでもない。

【０１３４】なお、上記全ての実施の形態に係る画像処理装置においては、被写体を撮像部により撮影する代わりに、ハードディスク等の記憶装置やＣＤ－ＲＯＭ等の記憶媒体に格納された２枚以上の被写体像を外部記憶部１８等に取り込み、これらの被写体像を用いて補正画像を生成してもよい。また、撮影モード設定部１９や基準画像設定部２０、対応検出部２１、画像歪み補正部２２及び画像合成部２４等が撮像部１１，４１とは別の筐体、例えば計算機等に収められているものも上記実施の形態と同様に考えられる。

【０１３５】また、対応検出部２１では、相関法による濃度マッチングにより対応点が検出されると説明したが、時空間微分法など別の手法で行っても良い。さらに、あおり歪みパラメータの算出においては、上記のような式（２０）に示された座標変換に限られず、他のパラメータ算出方法を適用してもよい。

［実施の形態５］上記実施の形態においては、画像処理の対象とする基準画像に対して座標変換パラメータを算出し、補間演算を用いて歪み補正画像が生成されたが、該基準画像は豊富な書画情報を含み、かつ補間演算による画像の劣化が少ない画像、すなわち比較的被写体に正対した状態で撮影された画像であることが好ましい。そこで、以下においては、最適な基準画像を自動的に選択する画像処理方法と、該方法を実行する画像処理装置について説明する。

【０１３６】図２９は、本発明の実施の形態５に係る画像処理装置における第一の構成例を示す図である。図２９に示されるように、本実施の形態５に係る画像処理装置５０は、図３に示された実施の形態１に係る画像処理装置１と同様な構成を有するが、基準画像設定部２０の代わりに被写体領域判定部２５と基準画像自動選択部２７とを備える点で相違するものである。

【０１３７】ここで、被写体領域判定部２５及び基準画像自動選択部２７は、それぞれ主制御部１４に接続され、被写体領域判定部２５の出力端は基準画像自動選択部２７に接続される。また、基準画像自動選択部２７の出力端は、画像歪み補正部２２に接続される。

【０１３８】なお、本実施の形態５に係る画像処理装置５０においても、図４に示されるように、上記実施の形態１に係る画像処理装置１と同様な構成とすることができる。

【０１３９】以下において、本実施の形態５に係る画像処理装置５０の動作を、図３０に示されたフローチャートを参照しつつ説明する。ここで、本実施の形態５に係る画像処理装置５０は、上記実施の形態１に係る画像処理装置１と同様に動作するため、以下においては相違点を中心に詳しく説明する。

【０１４０】まずステップＳ１において、ユーザにより、あおり補正モードを選択するか否か判断され、あおり補正モードが選択されず通常モードが選択される場合にはステップＳ１０へ進み、該ユーザにより所望のスナップ写真が撮影される。

【０１４１】一方、ステップＳ１においてユーザによりあおり補正モードが選択されるときには、ステップＳ２へ進む。そして、ステップＳ２においては、撮像部１１により少なくとも二回撮影された被写体像がフレームメモリ１５へ取り込まれる。なおこのとき、互いに該被写体像の一部が重なり合うように、各々の画像が撮影される必要がある。

【０１４２】次に、ステップＳ３において被写体像の入

力が終了したか否かが判断され、終了していない場合にはステップＳ２へ戻り、さらに被写体像の入力が継続される。一方、ユーザによる撮影終了の指示により被写体像の入力を終了した場合には、ステップＳ４へ進む。

【０１４３】そして、ステップＳ４では、対応検出部２１により被写体像の中において特徴点が検出され、該被写体像の少なくとも一部において重複する参照画像の中においては、上記特徴点と同一箇所を示す対応点が検出される。次に、特徴点と対応点の検出が終了すると、以下においてあおり歪みを補正する動作に入る。そしてまず、ステップＳ５において、基準画像自動選択部２７はあおり歪み補正の対象とする基準画像を自動選択する。以下において、基準画像自動選択部２７について詳しく説明する。

【０１４４】なお、上記実施の形態１に係る画像処理装置１と同様に、ステップＳ６においては、ステップＳ５において選択された基準画像に対してあおり歪みを補正するためのパラメータを計算し、ステップＳ７において該パラメータを基に画像のあおり歪みを補正した画像を作成し、動作を終了する。

【０１４５】あおり歪みを補正する場合、上記基準画像としては、撮影された複数の画像の中で被写体面が最も広い領域に渡って写っており、ユーザの必要とする書画情報量が豊富である画像が選択されると好適である。また、撮影時における撮像面の被写体面に対してなす角（以下において、「あおり角」とも呼ぶ）ができるだけ小さい画像が選択されると好適である。その理由について、図３１を参照しつつ説明する。

【０１４６】図２９に示された画像歪み補正部２２は、上記のように式（２５）による座標変換を実行することによってあおり歪み補正を行うが、あおり角φに応じて該補正動作が変化する。ここでは、説明を簡単なものにするためあおり角φがｙ軸周りに限られ、かつ被写体面に平行な被投影面３１の大きさが撮像面３２の大きさに等しいと仮定する。

【０１４７】図３１（ａ）に示されるように、あおり角φが比較的小さい場合における該座標変換においては、撮像面３２の左端近傍の点は、原点ｏに向かうベクトルで示される変分により被投影面３１へ投影される。なお、このような座標変換によって被投影面３１内における斜線部において、被写体像の解像度が低下する。

【０１４８】一方、図３１（ｂ）に示されるように、該座標変換においてあおり角φが比較的大きい場合には、撮像面３２の左端近傍の点は、図３１（ａ）に示される変分より大きな変分を伴い、すなわち原点ｏに対する位＊置ベクトルがより大きく縮小されるように被投影面３１に投影される。そして、該座標変換により被写体像の解像度が低下する領域は、図３１（ａ）の場合に比して大きくなることが分かる。

【０１４９】従って、以上より、あおり角φが小さいほど画像歪み補正部２２による座標変換に起因した解像度の劣化は少なくなることが分かる。

【０１５０】また、図２９に示された被写体領域判定部２５は、撮影した画像において被写体が占める領域を検出するが、例えば文献『画像の処理と認識』（安居院猛・長尾智晴共著、昭晃堂）に記載されているように、（ａ）領域成長法や領域分割法のように画像上でクラスタリングを行う方法、（ｂ）ヒストグラムによる領域分割など、特徴空間上でクラスタリングを行う方法、（ｃ）輪郭線追跡などの画像中のエッジを用いる方法、（ｄ）テクスチャ解析、などの領域分割方法が適用される。そして、被写体領域判定部２５は、該判定結果に応じて被写体の広い範囲を撮影した画像を上記基準画像として選択する。その結果、基準画像として豊富な書画情報を含む画像を自動的に選択することができる。

【０１５１】ここで、本発明の実施の形態５に係る画像処理装置は、図３２に示されるような構成とすることもできる。すなわち、図３２に示された画像処理装置５１は、図２９に示された画像処理装置５０と同様な構成を有するが、被写体領域判定部２５の代わりに直線状パターン検出部２８を備える点で相違するものである。

【０１５２】一般的に、文書を初めとする被写体面においては、文字列や罫線など互いに平行な関係にある直線状パターンが多数存在する。しかし、撮影時におけるあおり角が大きい場合には、本来平行であるはずの直線状パターンが、異なる向きを持つ直線状パターンとして画像に投影される。従って、画像に投影された直線状パターンの向きのばらつきを調べることにより該あおり角の大小を判別し、あおり角の小さな画像を自動的に基準画像として選択することができる。

【０１５３】ここで、図３２に示された直線状パターン検出部２８は、撮影された複数の画像において直線状パターンを検出する処理を行う。そして、以下に該直線状パターンの検出方法の一例を説明する。

【０１５４】まず、該複数の画像において微分を取ることにより、エッジ画像を作成する。次に、作成されたエッジ画像における断片的なエッジ点群を直線状セグメントに分割し、それぞれの直線状セグメントを以下の式（２８）に示される直線方程式に当てはめる。

$$ax+by+c=0 \quad (a^2+b^2=1) \qquad (28)$$

ここで、上記式（２８）への当てはめは、直線状セグメントを構成する点群を用いて、最小自乗法を適用することによりなされる。そして、直線状セグメントに対する直線の当てはめが終了すると、直線の向きを表すパラメータである（ａ，ｂ）のばらつきを求める。このようにして、上記複数の画像全てに対して（ａ，ｂ）のパラメータのばらつきを求めることにより、各画像における直線の向きのばらつきを知ることができる。そして、最も

直線の向きのばらつきが小さい画像を、自動的に基準画像として選択することができる。

【０１５５】また、基準画像の自動選択においては、以下のような方法を適用することもできる。まず、上記複数の画像において上記と同様な方法でエッジ画像を作成する。次に、該エッジ画像内の全ての点に対してHough変換を施す。ここでHough変換とは、断片的なエッジより直線を検出するために使用される数学的変換であり、検出したい線を表現する式のパラメータにより構成される空間で、クラスタリングする方法をいう。そして、より具体的には、画像上の点列をｘ軸となす角θと直線の長さρとにより示されるθ－ρ空間へ投影する。

【０１５６】図３３は、図３３（ａ）に示された画像空間から図３３（ｂ）に示されるθ－ρ空間へのHough変換を説明する図である。図３３に示されるように、Hough変換により画像上の各点Ｐ１～Ｐ３は、それぞれ対応する曲線Ｌ１～Ｌ３に変換される。そして、このような変換を画像上の全点について実行すると、θ－ρ空間において該曲線の軌跡が集中している点ＣＰが生じるが、この点ＣＰはエッジ画像において多くのエッジ点を通る直線に相当する。ここで、この点ＣＰの座標を（θ，ρ）とすれば、次の式（２９）に対応する直線が検出されたことになる。

$$\rho = x\cos\theta + y\sin\theta \qquad (29)$$

そして、上記複数の画像すべてに対し、該曲線が集中する点ＣＰを多数抽出し、これらの点におけるθのばらつきを求めることにより、各画像における直線の向きのばらつきを知ることができる。このようにして、最も直線の向きのばらつきが小さな画像を、自動的に基準画像として選択すれば良い。

【０１５７】図３４は、本発明の実施の形態５に係る画像処理装置における第三の構成例を示す図である。図３４に示されるように、本実施の形態５に係る画像処理装置は、図２９に示された被写体領域判定部２５や、図３２に示された直線状パターン検出部２８を備えることなく、基準画像自動選択部２７を対応検出部２１に接続することとしても良い。

【０１５８】上記対応検出部２１により検出された特徴点と対応点の組は射影変換行列Ｂ、すなわちあおり歪みを補正するパラメータの計算に使用される。このとき一般的には、該パラメータは、上記特徴点と対応点の組が多数あり、かつそれらが広範囲に分散しているほど精度良く算出される。そこで、撮影された複数の画像に対して、対応検出部２１により検出された特徴点と対応点の組、及びそれらの画像における分散を調べ、それらの値が最大である画像を自動的に基準画像として選択しても＊良い。

【０１５９】また、上記の相関法に基づく対応検出においては、一般的に画像中に特徴のあるパターンが多いほど、数多くの特徴点と対応点が検出される。そして、特徴のあるパターンが多いことは、ユーザにとって有用な書画情報が画像中に多く含まれている可能性が高いので、特徴点及び対応点が豊富な画像を基準画像として自動選択すれば、必要な書画情報を含む画像をあおり歪み補正の対象とすることができ好適である。

【０１６０】図３５は、本発明の実施の形態５に係る画像処理装置における第四の構成例を示す図である。図３５に示されるように、本実施の形態５に係る画像処理装置は、図２９に示された被写体領域判定部２５や、図３２に示された直線状パターン検出部２８の代わりに、平面計測部２９を備えることとしても良い。

【０１６１】ここで、平面計測部２９は、各画像の撮影時における撮像部１１に対する被写体の向きを計測する。図３６は、図３５に示された平面計測部２９の構成例を示す図である。図３６に示されるように、平面計測部２９はスポット光源２７１と、受光素子２７２と、３次元座標算出部２７３と、平面算出部２７４とを備え、スポット光源２７１は発光ダイオードや半導体レーザ等からなる光源２７１ａと、ポリゴンミラー等の走査ミラー２７１ｂと、走査ミラー２７１ｂの動きを制御する駆動部２７１ｃとを含む。

【０１６２】ここで、上記スポット光源２７１においては、光源２７１ａにより発生されたスポット光が被写体面ＰＬに当るように、走査ミラー２７１ｂが駆動部２７１ｃにより制御される。また、受光素子２７２は、スポット光源２７１に対する位置が予め測定されている場所に設置されたＰＳＤ（Position sensitive detector）やＣＣＤ等の光電変換素子により構成され、被写体面ＰＬからの反射光の向きを検出する。なお、撮像部１１に含まれた光電変換素子１１４を、上記における受光素子２７２として使用してもよい。

【０１６３】また、３次元座標算出部２７３は、スポット光源２７１が照射したスポット光の向きと、スポット光源２７１と受光素子２７２との位置関係、及び受光素子２７２が検出した反射光の向きに応じて、三角測量の原理を用いることにより画像処理装置５３を基準とした被写体面ＰＬの３次元座標（Ｘ，Ｙ，Ｚ）を算出する。そして、平面算出部２７４は、３次元座標算出部２７３により算出された同一直線上にない３点以上の３次元座標を用いて、平面方程式を推定する。例えば、求める平面方程式を、

$$aX + bY + cZ + d = 0 \quad (a^2 + b^2 + c^2 = 1,\ c > 0) \qquad (30)$$

とおき、３点以上の３次元座標を用いて、上記平面方程式における４つのパラメータ（ａ，ｂ，ｃ，ｄ）を最小自乗法により計算する。その結果、上記あおり角φは次式（３１）により計算される。

$$\phi = \cos^{-1} c \qquad (31)$$

従って、撮影された複数の画像全てに対して被写体面の

向きを計測し、そのあおり角φが最小である画像を自動的に基準画像として選択すればよい。

【０１６４】その他、画像歪み補正部２２の説明において記したように、対応検出部２１により検出された特徴点と対応点との組を用いることによっても、該被写体の向きを求めることができる。従って、本実施の形態５に係る画像処理装置は、いったん画像歪み補正部２２において式（１４）ないし式（１８）を実行して被写体の向きを求め、得られた結果を基準画像自動選択部２７へ出力するという構成とすることもできる。

［実施の形態６］以下においては、図１８に示されるように、同一の被写体面ＰＬにおける静止画像が、画像の一部においてそれぞれ重複するように複数の方向から撮影された場合を前提とした実施の形態を説明する。なお、ここでは図１８に示されるように、方向ｄ」から撮影することにより画像ｉｍｊ（１≦ｊ≦Ｋ）が得られ、例えば画像ｉｍ１と画像ｉｍ２のように隣り合う方向において撮影することにより得られた画像ｉｍｊと画像ｉｍ（ｊ＋１）（１≦ｊ≦Ｋ－１）との間ではそれぞれ重複領域があるものとする。そして、本実施の形態６に係る画像処理装置においては、基準画像として選択されたいずれか一つの画像に整合するように、他の画像が貼り合わされ合成画像が生成される。

【０１６５】図３７は、本発明の実施の形態６に係る画像処理装置６０の構成を示す図である。図３７に示されるように、本実施の形態６に係る画像処理装置６０は、図１９に示された実施の形態２に係る画像処理装置６と同様な構成を有するが、基準画像設定部２０の代わりに基準画像自動選択部２７を備える点で相違するものである。

【０１６６】上記のような構成を有する本実施の形態６に係る画像処理装置６０は、実施の形態２に係る画像処理装置６と同様に動作するが、以下において、本実施の形態６に係る画像処理装置６０の動作を、図３８に示されたフローチャートを参照しつつ相違点を中心に説明する。

【０１６７】まずステップＳ１において、ユーザにより、画像合成モードを選択するか否か判断され、画像合成モードが選択されず通常モードが選択される場合にはステップＳ１０へ進み、該ユーザにより所望のスナップ写真が撮影される。

【０１６８】一方、ステップＳ１においてユーザにより画像合成モードが選択されるときには、ステップＳ２へ進む。そして、ステップＳ２においては、撮像部１１により撮影された複数の被写体像がフレームメモリ１５へ取り込まれる。なおこのとき、互いに該被写体像の一部が重なり合うように、各々の画像が撮影される必要がある。

【０１６９】次に、ステップＳ３において被写体像の入力が終了したか否かが判断され、終了していない場合にはステップＳ２へ戻り、さらに被写体像の入力が継続される。一方、ユーザによる撮影終了の指示により被写体像の入力を終了した場合には、ステップＳ４へ進む。

【０１７０】そして、ステップＳ４では、対応検出部２１により画像ｉｍｊと画像ｉｍ（ｊ＋１）との間において特徴点が検出され、該画像ｉｍｊの少なくとも一部において重複する画像ｉｍ（ｊ＋１）の中においては、上記特徴点と同一箇所を示す対応点が検出される。

【０１７１】次に、該特徴点と該対応点の検出が終了すると、以下において複数枚の画像を貼り合せた合成画像を生成する動作に入る。そしてまずステップＳ５において、基準画像自動選択部２７は、該合成において基準とする基準画像を自動的に選択する。ここで、基準画像自動選択部２７は、上記あおり角ができるだけ小さい画像を自動的に基準画像として選択する。そして、このような選択を行うことにより、あおり歪みの小さな合成画像を得ることができる。

【０１７２】そして、ステップＳ６においては、ステップＳ５において選択された基準画像を基準とした合成を行うための射影変換行列を算出し、ステップＳ７において該射影変換行列を用いて合成画像を生成し、動作を終了する。

［実施の形態７］図３９は、本発明の実施の形態７に係る画像処理装置の構成を示す図である。図３９に示されるように、本実施の形態７に係る画像処理装置７０は、図３に示された実施の形態１に係る画像処理装置１と同様な構成を有するが、基準画像自動選択部２７と、切り替え部４５とをさらに備える点で相違するものである。

【０１７３】ここで、基準画像自動選択部２７は主制御部１４により制御される。また、切り替え部４５はその入力端が基準画像設定部２０及び基準画像自動選択部２７に接続されると共に、出力端が画像歪み補正部２２に接続される。

【０１７４】また、切り替え部４５は、基準画像の選択方法を切り替えるものであり、図４０に示されるように、上方向スクロールキー２０１と下方向スクロールキー２０２、及び決定キー２０３とを含む。ここで、表示部１７に表示されるメニューキー（図示していない）をユーザが選択的に押すことにより、図４０に示されるような「基準画像の選択」という文字がオーバレイ表示された画面が表示部１７に表示される。

【０１７５】そして、上方向スクロールキー２０１又は下方向スクロールキー２０２が該ユーザにより操作されることにより、図４０に示された三角形のカーソルが上下移動する。このとき、該カーソルが「ＡＵＴＯ」の文字を指している状態において決定キー２０３が押されると基準画像を自動的に選択することが決定され、図３９に示された基準画像自動選択部２７が選択的に活性化される。一方、該カーソルが「ＭＡＮＵＡＬ」の文字を指している状態において決定キー２０３が押されると基準

画像を手動により設定することが決定され、図３９に示された基準画像設定部２０が選択的に活性化される。

【０１７６】従って、本実施の形態７に係る画像処理装置によれば、切り替え部４５による切り替えにより、基準画像設定部２０又は基準画像自動選択部２７のいずれか一方を選択的に画像歪み補正部２２に接続することができるため、ユーザは基準画像の選択方法として自動又は手動のいずれかを任意に選択することができる。

【０１７７】なお、上述したいずれの実施の形態においても、該実施の形態に係る画像処理方法をコンピュータプログラムとして記述することができる。そして、図４１に示されるように、該プログラムを格納した記録媒体３０１を画像処理装置１に装着し、画像処理装置１に該プログラムを実行させることにより、上記画像処理を容易に実現することができる。

【０１７８】また、図４２に示されるように、該プログラムを格納したＣＤ－ＲＯＭ３０２をパーソナルコンピュータ（パソコン）ＰＣに装着し、該プログラムをパソコンＰＣで実行することによっても、上記画像処理を実現することができる。なお、パソコンＰＣへ装着され該プログラムを格納する記録媒体としては、上記ＣＤ－ＲＯＭ３０２に限られず、例えばＤＶＤ－ＲＯＭ等であってもよいことはいうまでもない。

【０１７９】以下において、上記画像処理方法を該プログラムの実行により実現する場合の具体例を説明する。この場合には、画像処理装置１及びパソコンＰＣは、内蔵されたメモリやハードディスクなどの記憶装置及びＣＤ－ＲＯＭ等の記録媒体に格納された２枚以上の被写体像を、計算機に搭載された各種インタフェースを介して上記信号処理部１２へ取り込む。

【０１８０】また、上記における撮影モードの設定は、パソコンＰＣのキーボードにおける所定のキーを押し、又は画面上に表示されたアイコンをマウスクリックすることにより遂行される。一方、基準画像を手動により選択する場合には、入力された複数の画像を画面上に間引きして表示し、計算機に使用されるキーボードの上下カーソルキーを押すか、あるいはマウスによりアイコンをクリックすること等により、上記間引きされた画像が選択される。そして、所望の画像が選択された状態で改行キーが押されると、該画像が基準画像として設定される。

【０１８１】また、撮像部１１を構成する光学系の焦点距離ｆについては、予め該光学系の焦点距離を測定しておき、該記録媒体の内部に記録しておく。そして、ユーザは画面上において、実際の撮影の際に使用した光学系の焦点距離を選択する。ここで、該焦点距離はヘッダ情報として記録しておくこともできる。すなわち、例えば画像データとしてExifフォーマットを使用する場合、そのヘッダ情報として撮影時の焦点距離を記録することができる。そして、本実施の形態に係る画像処理装置はこのヘッダ情報を読み取ることにより、該焦点距離を得ることができる。なお、上記のような方法が取れない場合には、ダイアログボックス等をパソコンＰＣなどの画面に表示して、該ダイアログボックス内においてユーザに直接焦点距離を手入力させるとよい。

【０１８２】また、上記における被写体の向きについても、上記焦点距離と同様に扱うことができる。すなわち、平面計測部２９又は画像歪み補正部２２により計測された被写体の向きを、予め画像データファイル内のヘッダ情報として記録しておき、本実施の形態に係る画像処理装置は該ヘッダ情報を読み込むことにより該被写体の向きを得ることとしても良い。

【０１８３】このとき、例えば画像データとしてExifフォーマットを使用する場合には、被写体の向きを記録するためのフィールドは存在しないが、Maker Noteと呼ばれる製造者が自由に利用できるフィールドに被写体の向きを記録することができる。

【０１８４】また、上記のような方法を取ることが出来ない場合には、焦点距離の場合と同様に、ダイアログボックス等をパソコンＰＣ等の画面上に表示して、ユーザに直接被写体の向きを入力させるようにすると良い。

【０１８５】なお、上記本発明の実施の形態は、デジタルスチルカメラやデジタルビデオカメラを利用した紙面情報入力、分割画像の貼り合わせ合成等の画像処理に適用でき、また非接触ハンディスキャナやその他の画像機器にも応用できる。

【発明の効果】上述の如く、本発明によれば、被写体に対して少なくとも一部が重複するよう複数の方向から撮影された画像の歪みを補正する画像処理方法において、複数の画像の中から歪みを補正する対象を選択することにより、適正な画像を得るために最適な画像を補正対象とすることができるため、より精度のよい該補正を実現することができる。

【０１８６】また、複数の画像の中から歪みが最も少ない画像を選択して、歪みを補正した画像を該選択された画像と合成すれば、より適正な合成画像を得ることができる。

【０１８７】ここで、画像内において被写体が占める領域の広さに応じて補正の対象を自動的に選択すれば、必要とされる書画情報量が最も豊富な画像の歪みを自動的に補正することができるため、確実に適正な画像を得ることができる。

【０１８８】また、画像内において検出される直線状パターンの向きに応じて補正の対象を自動的に選択すれば、被写体にほぼ正対した位置から撮影された画像を自動的に補正対象とすることができるため、解像度が高い適正な画像を得ることができる。

【０１８９】また、特定された対応関係に応じて補正の対象を自動的に選択すれば、精度の高い補正を確実に実行することができるため、画像処理の信頼性を高めるこ

とができる。

【０１９０】また、撮影毎に検出された被写体の向きに応じて補正の対象を自動的に選択すれば、被写体に対してほぼ正対した位置から撮影された画像を自動的に補正対象とすることができるため、解像度が高い適正な画像を得ることができる。

【０１９１】また、次に撮影する画像が歪みを補正する際の基準とされる画像となることをユーザへ通知する通知手段を備えた画像処理装置によれば、歪みを補正する際に基準とされる画像の撮影においてユーザへ注意が喚起されるため、ユーザの不注意などによる撮影ミスが回避され、動作の信頼性及び補正画像の品質を高めることができる。

【０１９２】また、被写体を同時に撮影する複数の光学手段と、複数の光学手段で撮影される画像のうち補正の対象とする画像を選択する選択手段とを備えた画像処理装置によれば、一度の撮影により複数の方向から撮影された複数の被写体像を得ることができるため、歪みを補正するために必要とされる撮影回数を減少させることによって操作が簡便にされると共に、より簡易に歪み補正がされた画像を得ることができる。

【図面の簡単な説明】

【図１】従来の技術における問題点を説明するための図である。

【図２】本発明の実施の形態１に係る画像処理方法及び画像処理装置を説明するための図である。

【図３】本発明の実施の形態１に係る画像処理装置の構成を示す図である。

【図４】図３に示された画像処理装置を示す斜視図である。

【図５】本発明の実施の形態１に係る画像処理装置の動作を示すフローチャートである。

【図６】図３に示された表示部における撮影時の表示例を示す図である。

【図７】図３に示された基準画像設定部のレイアウトを示す図である。

【図８】本発明の実施の形態１に係る画像処理装置の他の例を示す図である。

【図９】図３に示された対応検出部の構成を示す図である。

【図１０】図９に示された相関演算部の動作を説明する図である。

【図１１】図３に示された画像歪み補正部の構成を示す図である。

【図１２】図３に示された画像歪み補正部の動作を説明する第一の図である。

【図１３】図３に示された撮像部の光学系を説明する図である。

【図１４】図１１に示された３次元演算部による射影変換を説明する図である。

【図１５】図３に示された画像歪み補正部の動作を説明する第二の図である。

【図１６】図１１に示されたパラメータ算出部の動作を説明する第一の図である。

【図１７】図１１に示されたパラメータ算出部の動作を説明する第二の図である。

【図１８】本発明の実施の形態２に係る画像処理方法及び画像処理装置を説明するための図である。

【図１９】本発明の実施の形態２に係る画像処理装置の構成を示す図である。

【図２０】本発明の実施の形態２に係る画像処理装置の動作を示すフローチャートである。

【図２１】図１９に示された画像合成部の構成を示す図である。

【図２２】本発明の実施の形態３に係る画像処理装置の構成を示す図である。

【図２３】本発明の実施の形態３に係る画像処理装置の動作を示すフローチャートである。

【図２４】図２２に示された基準画像設定部に対する基準画像の設定を説明する図である。

【図２５】図２２に示された通知部の動作を説明する図である。

【図２６】本発明の実施の形態４に係る画像処理装置の構成を示す図である。

【図２７】本発明の実施の形態４に係る画像処理装置の動作を示すフローチャートである。

【図２８】図２６に示された基準画像設定部に対する基準画像の設定を説明する図である。

【図２９】本発明の実施の形態５に係る画像処理装置における第一の構成例を示す図である。

【図３０】本発明の実施の形態５に係る画像処理装置の動作を示すフローチャートである。

【図３１】解像度劣化におけるあおり角依存性を説明する図である。

【図３２】本発明の実施の形態５に係る画像処理装置における第二の構成例を示す図である。

【図３３】本発明の実施の形態５に係る画像処理方法において用いられるHough変換を説明する図である。

【図３４】本発明の実施の形態５に係る画像処理装置における第三の構成例を示す図である。

【図３５】本発明の実施の形態５に係る画像処理装置における第四の構成例を示す図である。

【図３６】図３５に示された平面計測部の構成を示す図である。

【図３７】本発明の実施の形態６に係る画像処理装置の構成を示す図である。

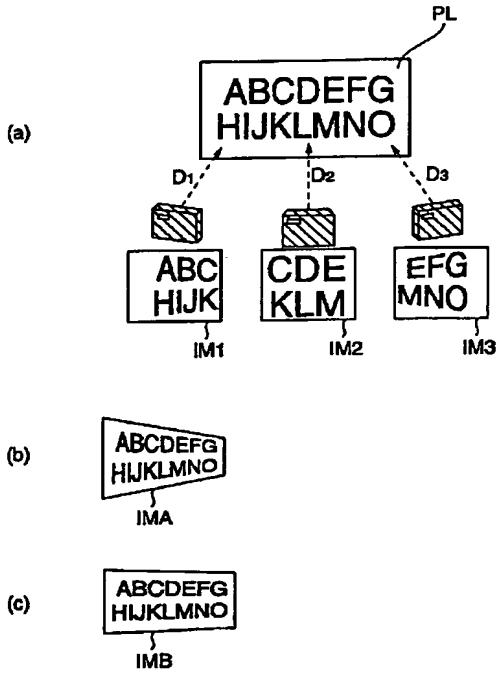
【図３８】本発明の実施の形態６に係る画像処理装置の動作を示すフローチャートである。

【図３９】本発明の実施の形態７に係る画像処理装置の構成を示す図である。

【図４０】図３９に示された切り替え部の動作を説明する図である。
【図４１】本発明の実施の形態に係る画像処理装置と記録媒体を示す図である。
【図４２】本発明の実施の形態に係るコンピュータとコンピュータ読み取り可能な記録媒体を示す図である。
【符号の説明】
１，２，６，８，４０，５０～５３，６０，７０　画像処理装置
３，４，１０，ＩＭ１～ＩＭ３，ｉｍ１，ｉｍ２，ｉｍｊ，ｉｍｋ　画像
５　歪み補正画像
７　基準画像
９　参照画像
１１，４１　撮像部
１１Ａ，１１Ｂ　光学系
１２　信号処理部
１３　メモリ制御部
１４　主制御部
１５　フレームメモリ
１６　インタフェース（Ｉ／Ｆ）
１７　表示部
１８　外部記憶部
１９　撮影モード設定部
２０　基準画像設定部
２１　対応検出部
２２　画像歪み補正部
２３　被写体領域決定部
２４　画像合成部
２５　被写体領域判定部
２６　通知部
２７　基準画像自動選択部
２８　直線状パターン検出部
２９　平面計測部
３０　画像面
３１　被投影面
３２　撮像面
３３　装置座標系
３５　被写体像
４５　切り替え部
１０１　電源スイッチ
１０２　シャッター
１０３　ファインダ
１０４　撮影モード設定キー
１１１　レンズ
１１２　絞り
１１３　シャッター
１１４　光電変換素子
１１５　前処理部
２０１　上方向スクロールキー
２０２　下方向スクロールキー
２０３　決定キー
２０４　カーソルキー
２１１　特徴点設定部
２１２　相関演算部
２１３　特徴点
２１５，２１６　相関窓
２１７　対応点
２２１　３次元演算部
２２２　パラメータ算出部
２２３　座標変換部
２２４　画像面
２３１　射影変換算出部
２３２　座標変換部
２４１　ファインダ
２４２　インジケータ
２７１　スポット光源
２７１ａ　光源
２７１ｂ　走査ミラー
２７１ｃ　駆動部
２７２　受光素子
２７３　３次元座標算出部
２７４　平面算出部
３０１　記録媒体
３０２　ＣＤ－ＲＯＭ
ＰＬ　被写体面
ＰＣ　パーソナルコンピュータ（パソコン）
D_1～D_3，d_1，d_2，d_j，d_k　方向
ＩＭＡ，ＩＭＢ，ＩＭＣ　合成画像

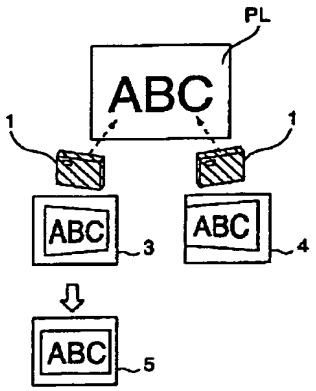
【図１】

従来の技術における問題点を説明するための図



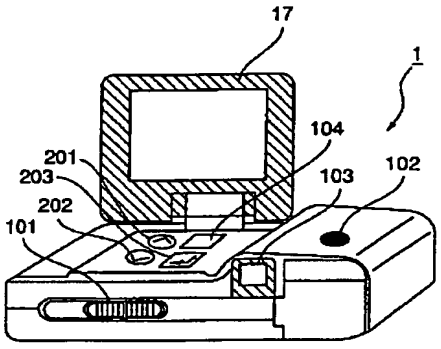
【図２】

本発明の実施の形態1に係る画像処理方法及び画像処理装置を説明するための図



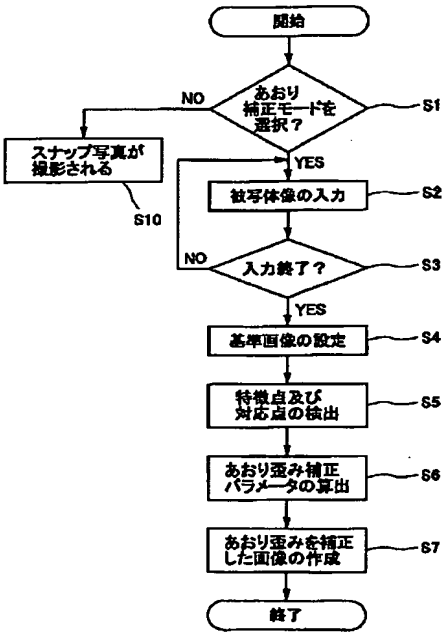
【図４】

図3に示された画像処理装置を示す斜視図



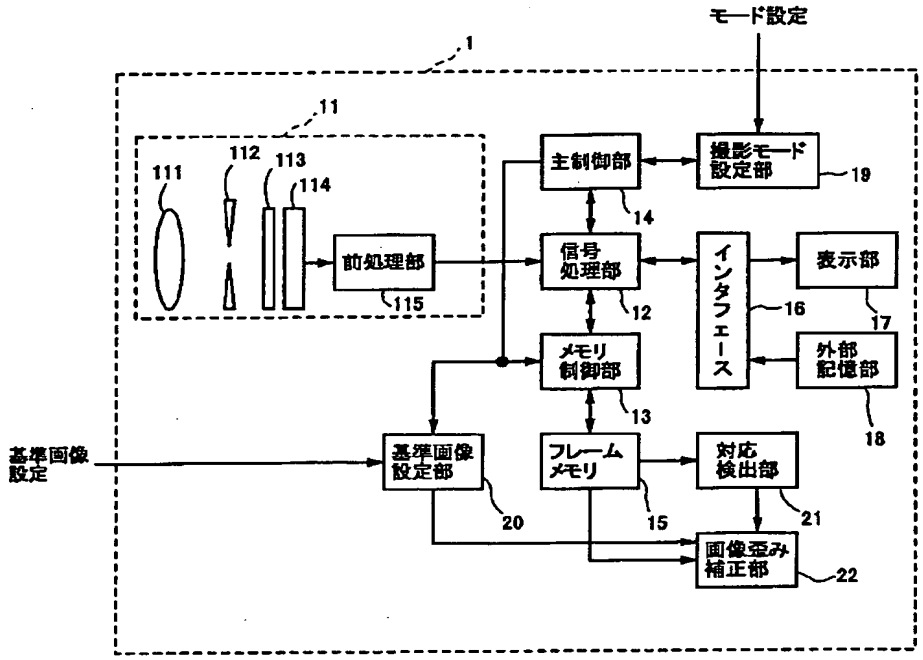
【図５】

本発明の実施の形態1に係る画像処理装置の動作を示すフローチャート



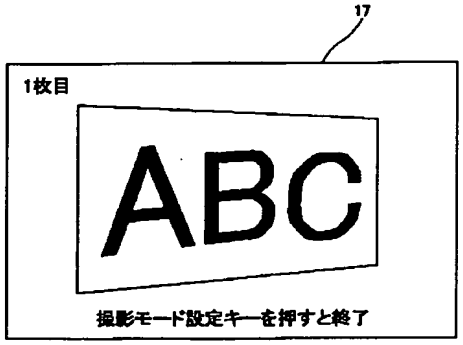
【図３】

本発明の実施の形態1に係る画像処理装置の構成を示す図



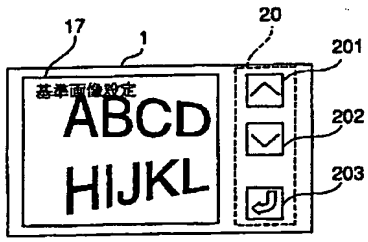
【図６】

図3に示された表示部における撮影時の表示例を示す図



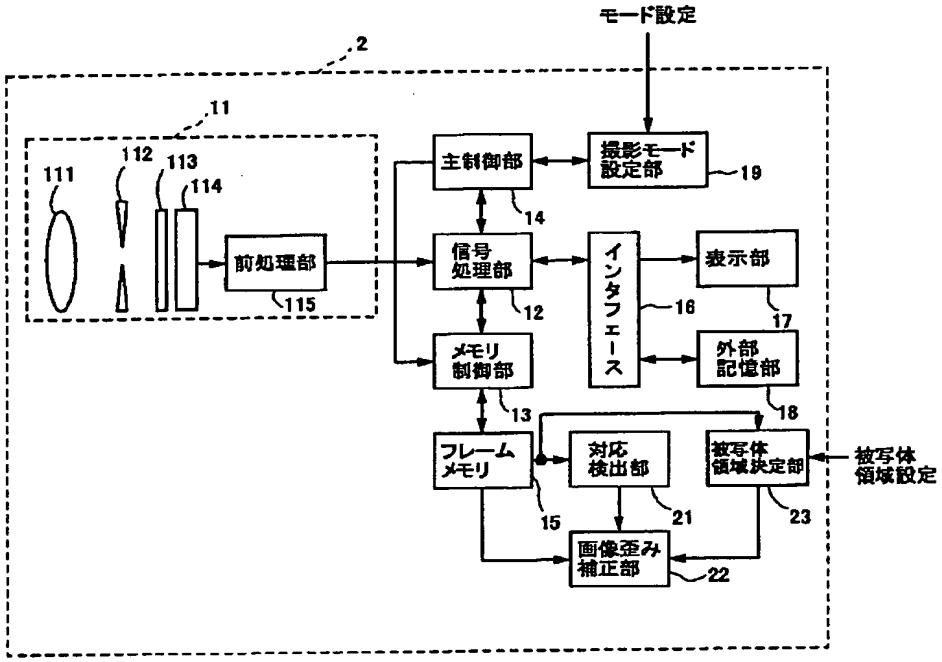
【図７】

図3に示された基準画像設定部のレイアウトを示す図



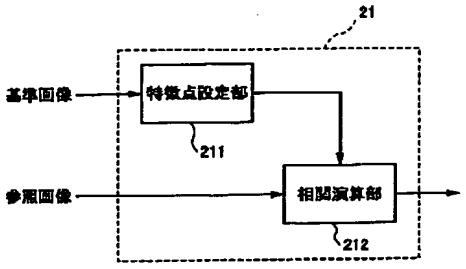
【図８】

本発明の実施の形態1に係る画像処理装置の他の例を示す図



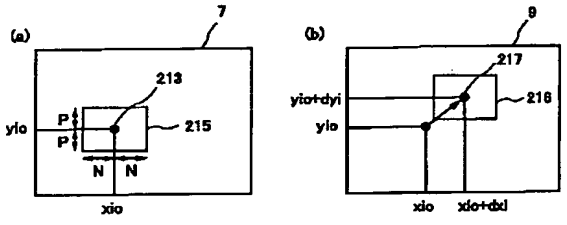
【図９】

図3に示された対応検出部の構成を示す図



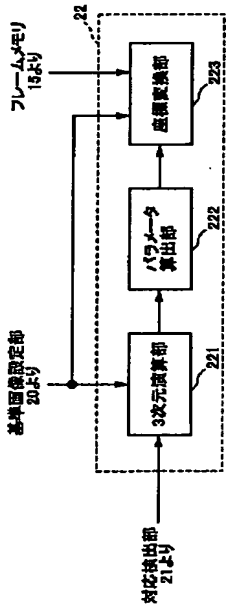
【図１０】

図9に示された相関演算部の動作を説明する図



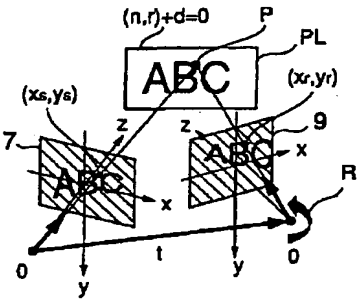
【図１１】

図3に示された画像歪み補正部の構成を示す図



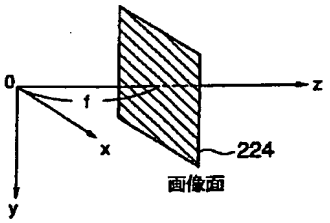
【図１２】

図3に示された画像歪み補正部の動作を説明する第一の図



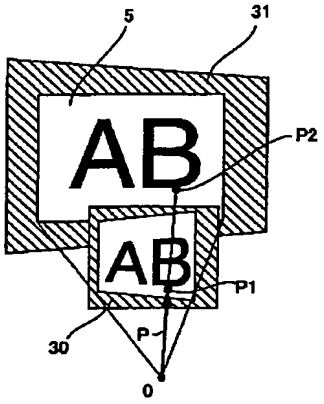
【図１３】

図3に示された撮像部の光学系を説明する図



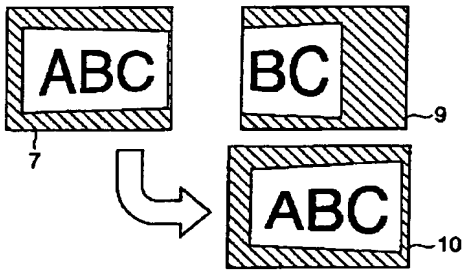
【図１５】

図3に示された画像歪み補正部の動作を説明する第二の図



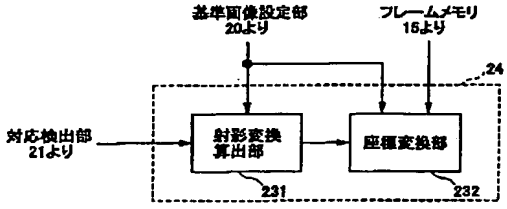
【図１４】

図11に示された3次元演算部による射影変換を説明する図



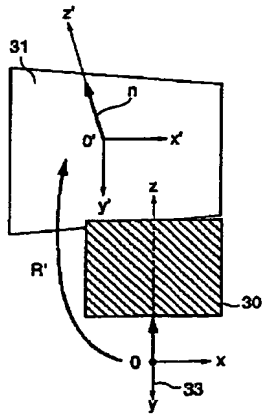
【図２１】

図19に示された画像合成部の構成を示す図



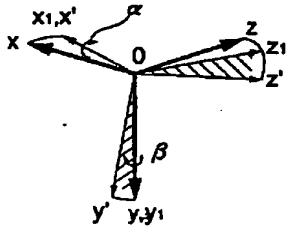
【図１６】

図11に示されたパラメータ算出部の動作を説明する第一の図



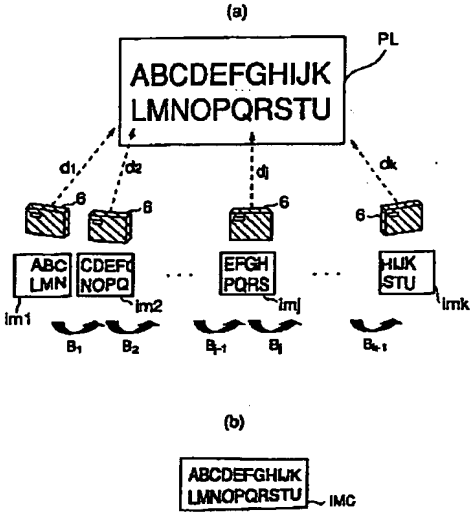
【図１７】

図11に示されたパラメータ算出部の動作を説明する第二の図



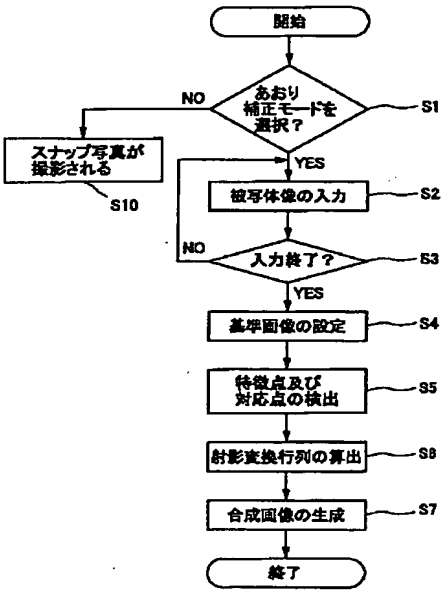
【図１８】

本発明の実施の形態2に係る画像処理方法及び画像処理装置を説明するための図



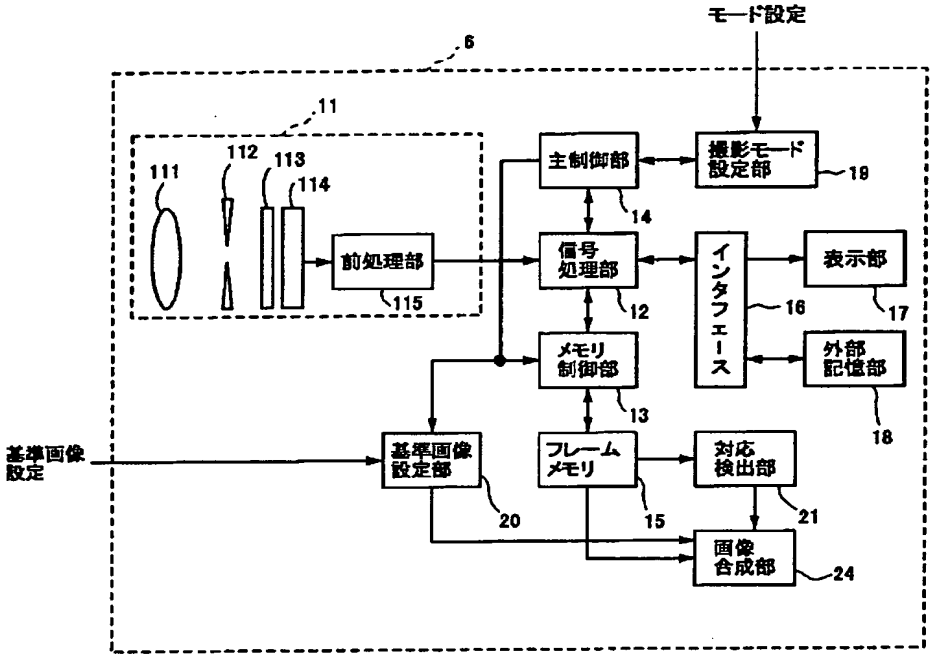
【図２０】

本発明の実施の形態2に係る画像処理装置の動作を示すフローチャート



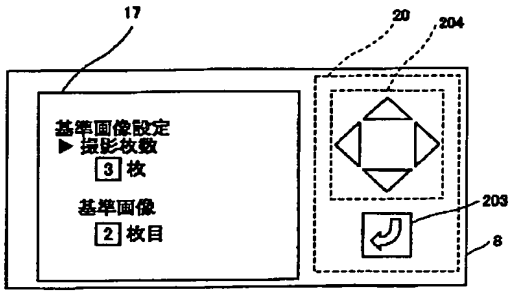
【図１９】

本発明の実施の形態2に係る画像処理装置の構成を示す図



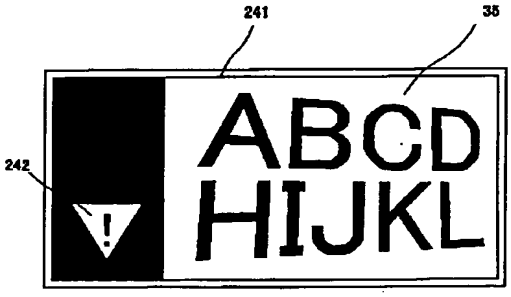
【図２４】

図22に示された基準画像設定部に対する基準画像の設定を説明する図



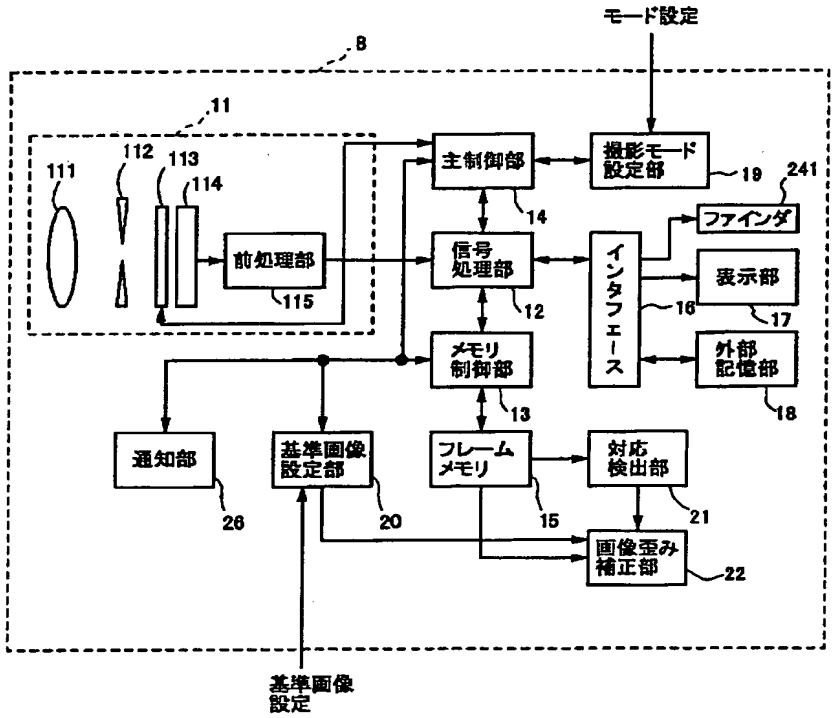
【図２５】

図22に示された通知部の動作を説明する図



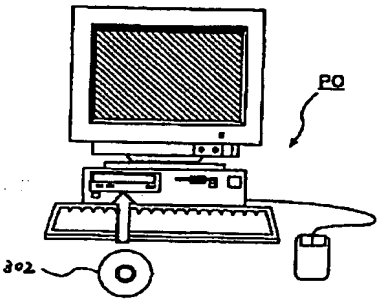
【図２２】

本発明の実施の形態3に係る画像処理装置の構成をを示す図



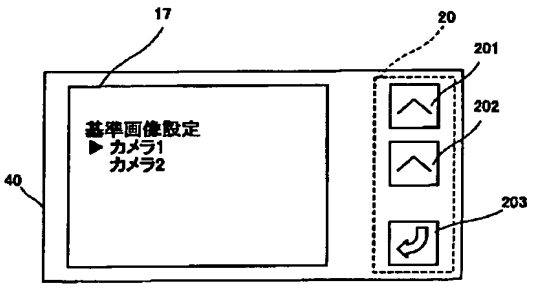
【図４２】

本発明の実施の形態に係るコンピュータとコンピュータ読み取り可能な記録媒体を示す図



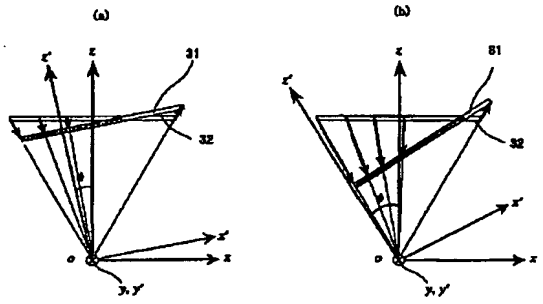
【図２８】

図26に示された基準画像設定部に対する基準画像の設定を説明する図



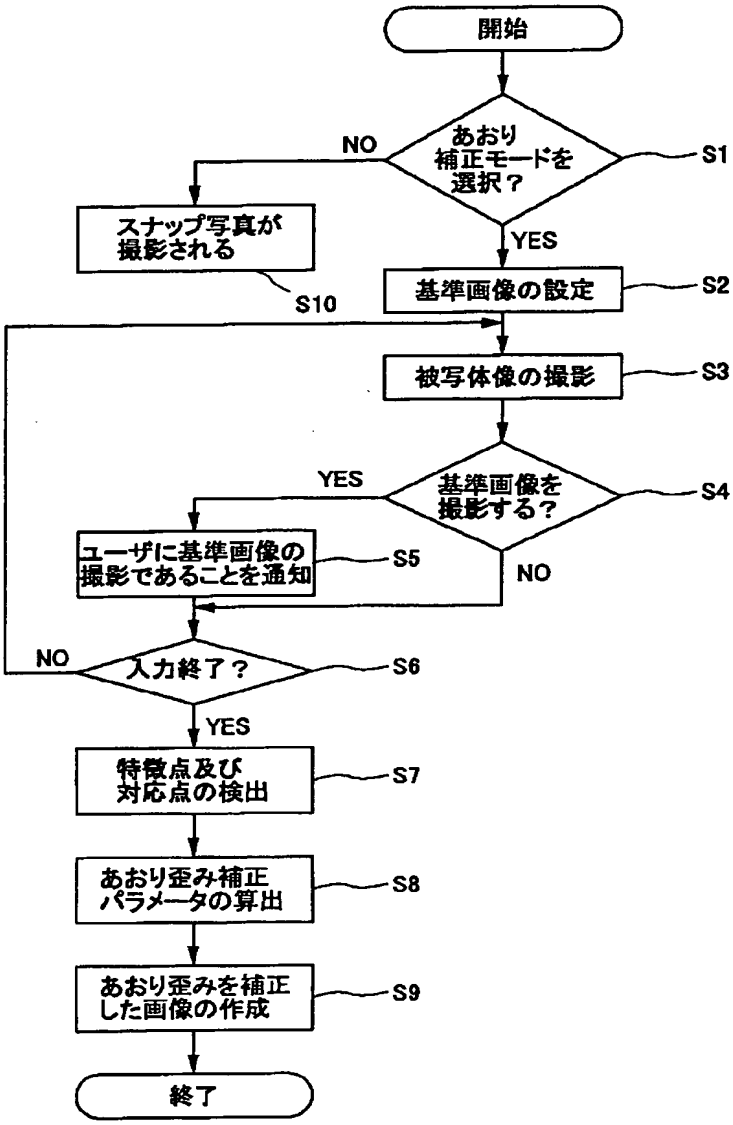
【図３１】

解像度劣化におけるあおり角依存性を説明する図



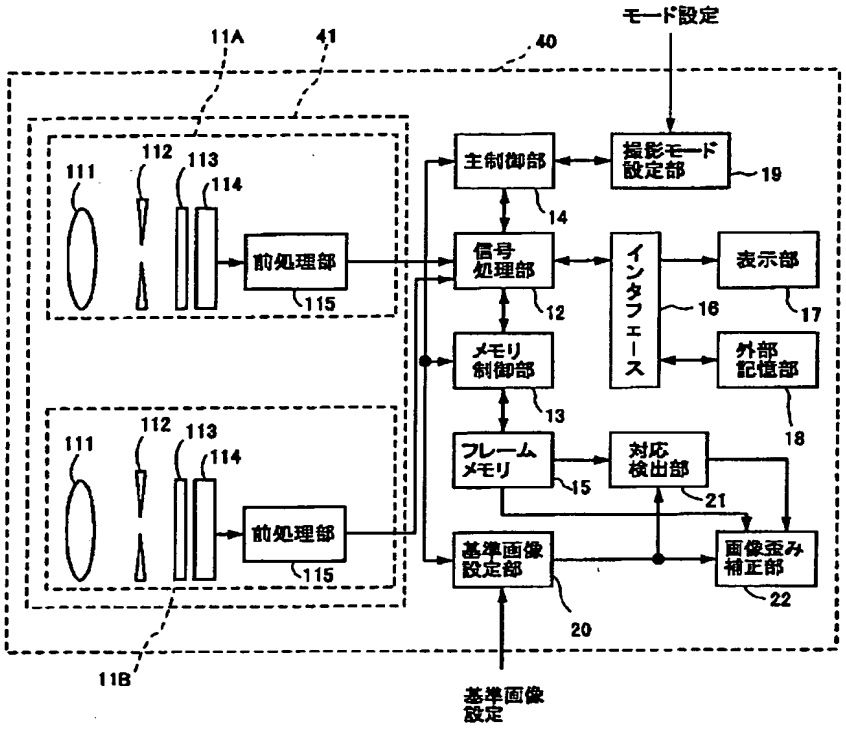
【図２３】

本発明の実施の形態3に係る画像処理装置の動作を示すフローチャート



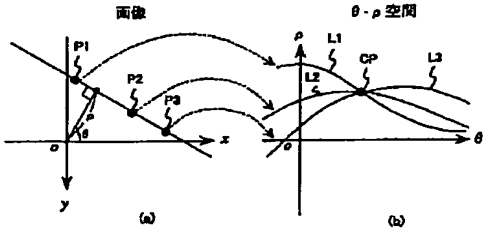
【図２６】

本発明の実施の形態4に係る画像処理装置の構成を示す図



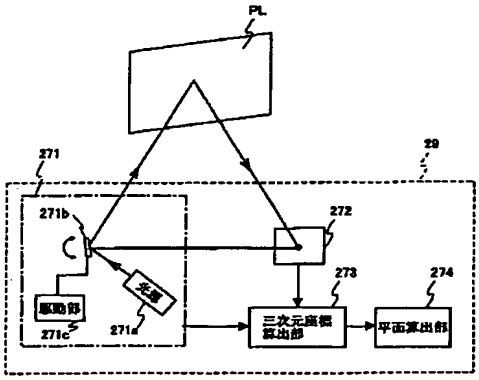
【図３３】

本発明の実施の形態5に係る画像処理方法において用いられるHough変換を説明する図



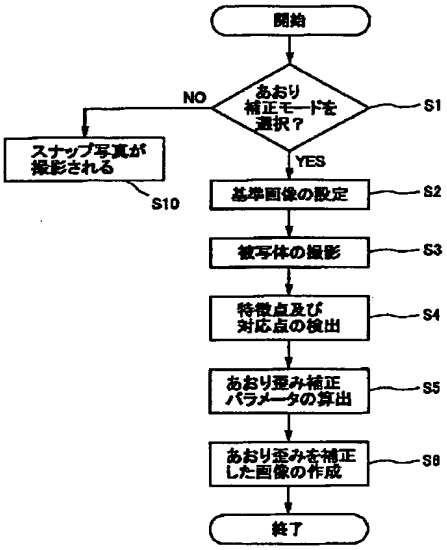
【図３６】

図35に示された平面計測部の構成を示す図



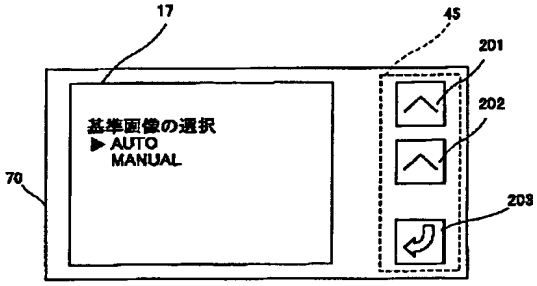
【図２７】

本発明の実施の形態4に係る画像処理装置の動作を示すフローチャート



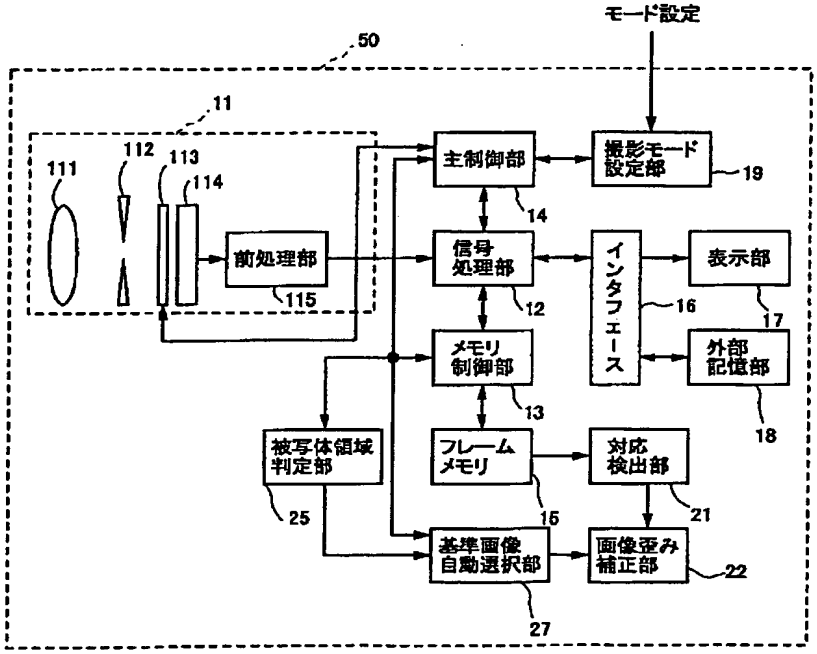
【図４０】

図39に示された切り替え部の動作を説明する図



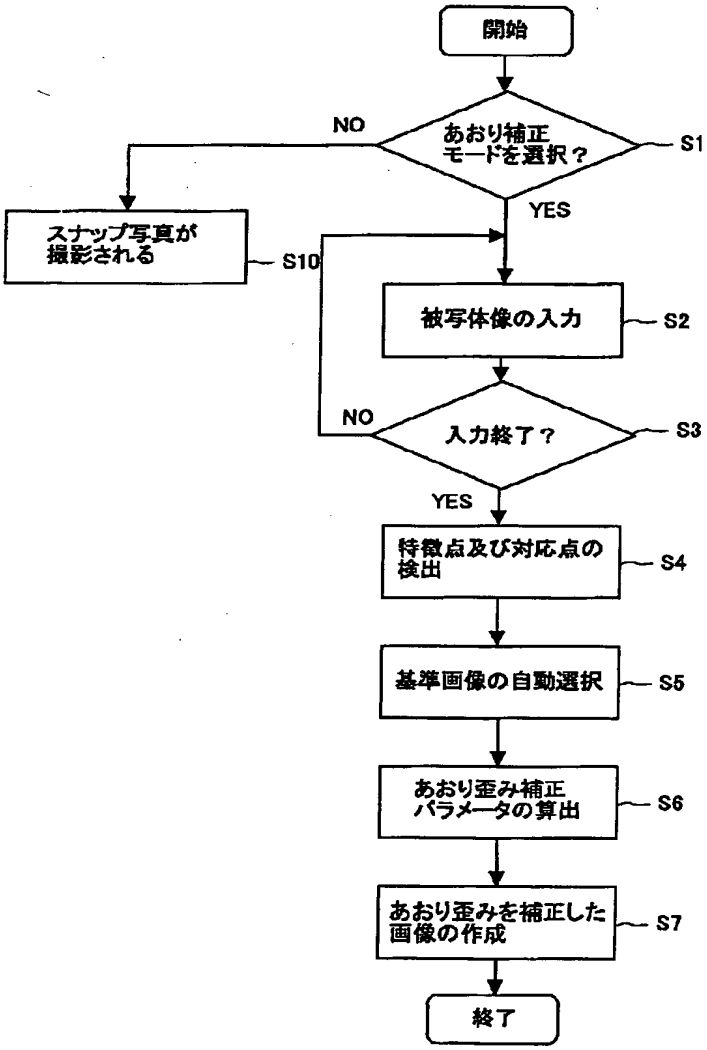
【図２９】

本発明の実施の形態5に係る画像処理装置における第一の構成例を示す図



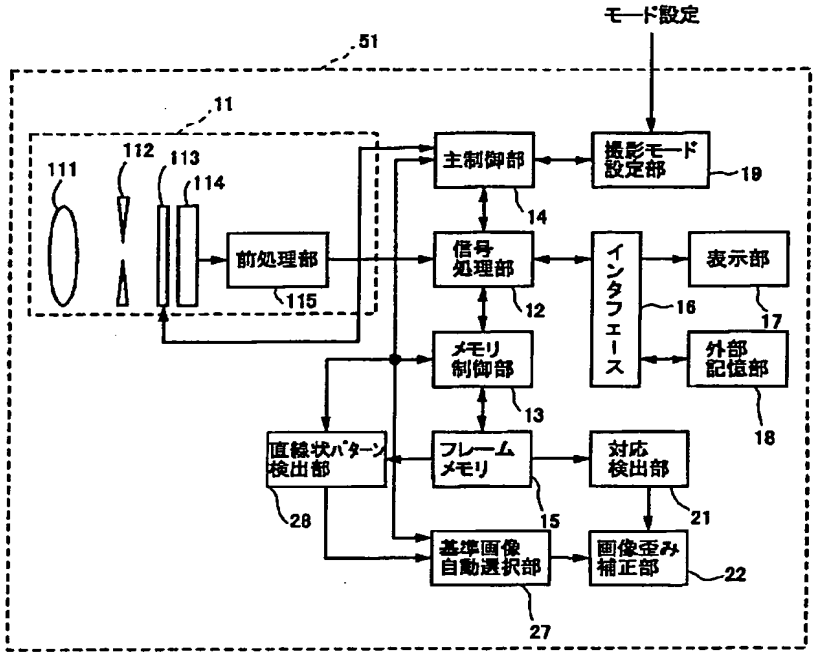
【図３０】

本発明の実施の形態5に係る画像処理装置　の動作を示すフローチャート



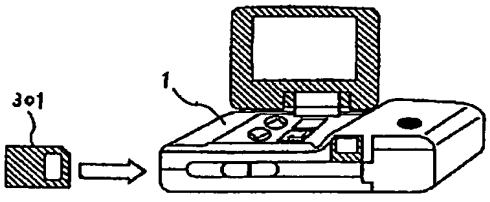
【図３２】

本発明の実施の形態5に係る画像処理装置における第二の構成例を示す図



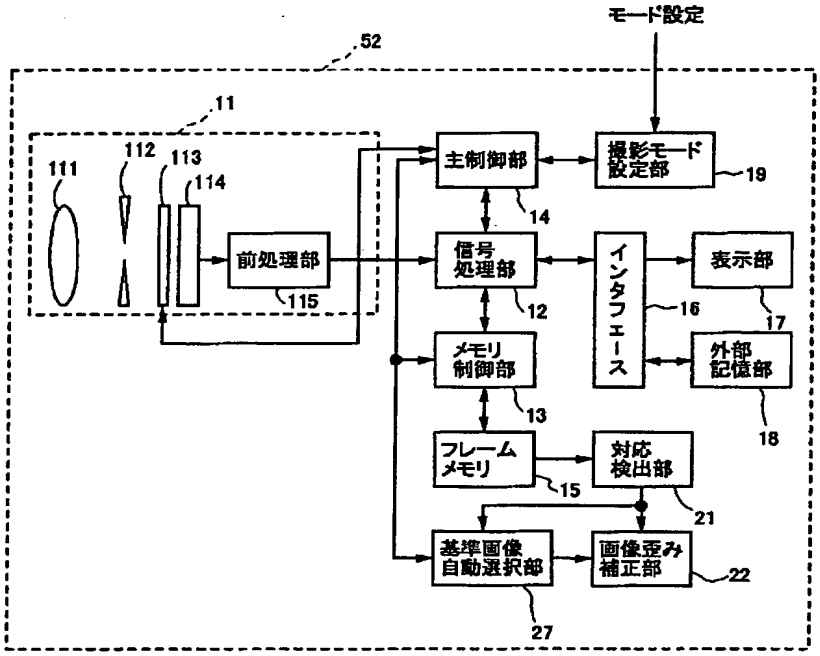
【図４１】

本発明の実施の形態に係る映像処理装置と記録媒体を示す図



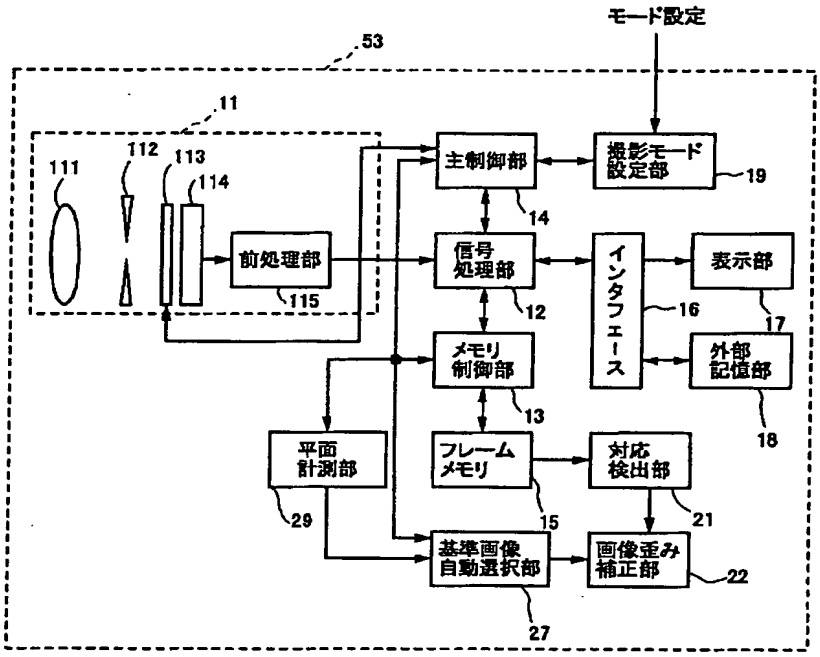
【図３４】

本発明の実施の形態5に係る画像処理装置における第三の構成例を示す図



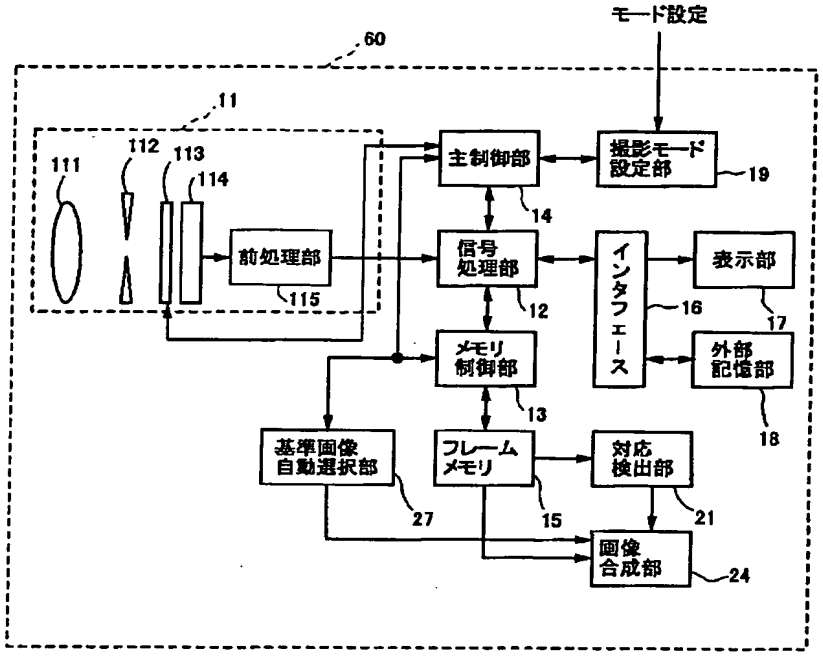
【図３５】

本発明の実施の形態5に係る画像処理装置における第四の構成例を示す図



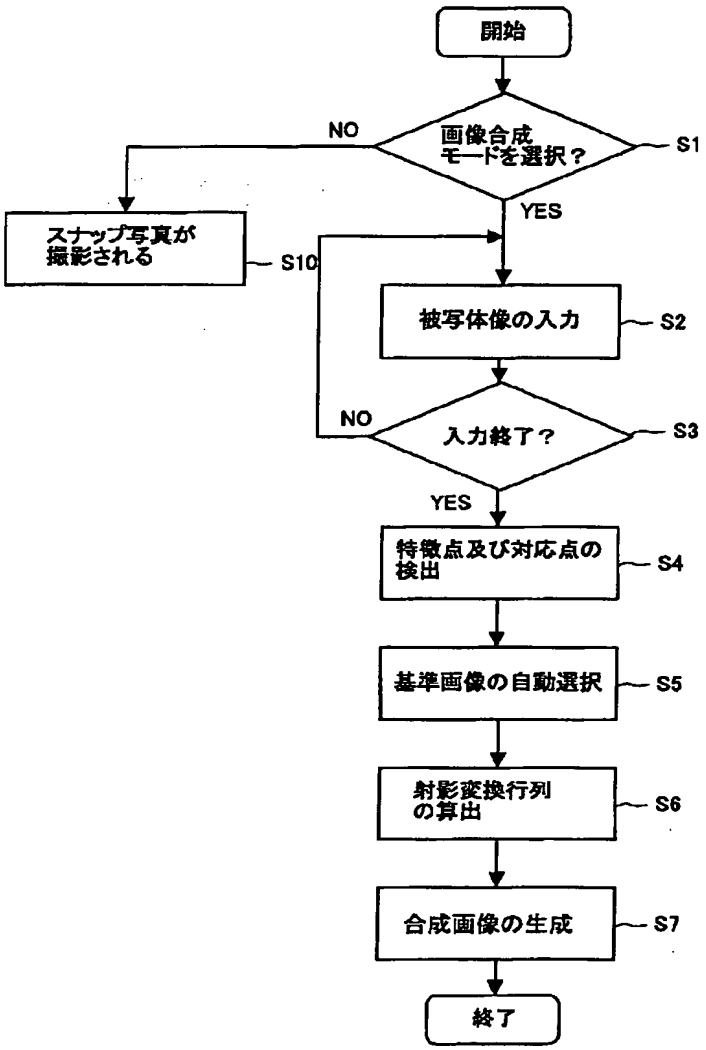
【図３７】

本発明の実施の形態6に係る画像処理装置の構成を示す図



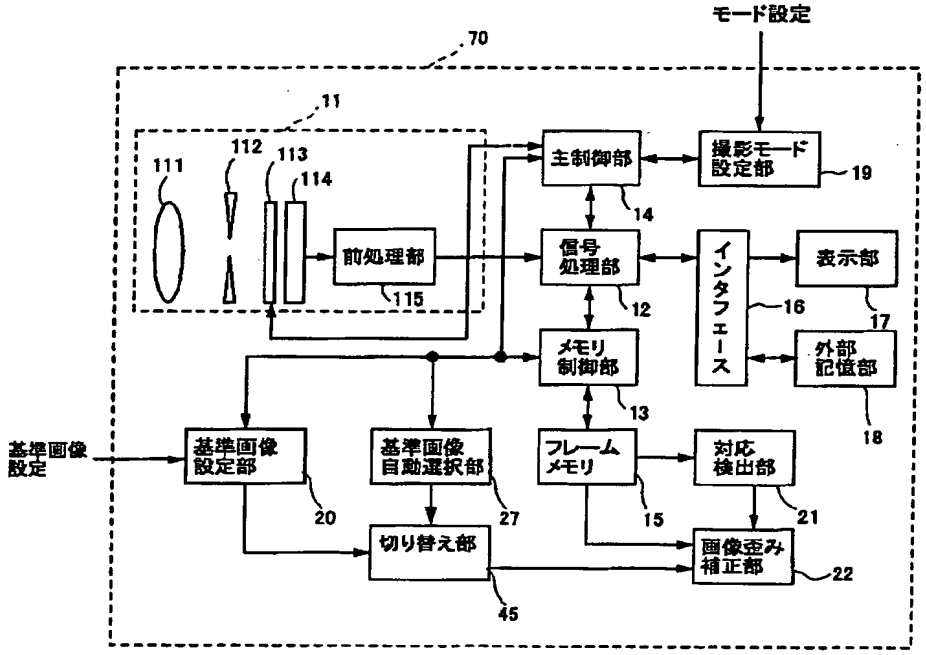
【図３８】

本発明の実施の形態6に係る画像処理装置　の動作を示すフローチャート



【図３９】

本発明の実施の形態7に係る画像処理装置の構成を示す図



フロントページの続き

(72)発明者　青木　伸
東京都大田区中馬込１丁目３番６号　株式会社リコー内

Ｆターム(参考)　5B057 BA02 CD12 CD20 CE10
5C023 AA10 AA11 AA31 AA34 AA37 CA01 DA01 EA03
5C076 AA12 AA23 AA40 BA01 BA06

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record.

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☑ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☑ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: _____

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.